

STATE OF CALIFORNIA
GOODWIN J. KNIGHT
GOVERNOR

PUBLICATION OF
STATE WATER RESOURCES BOARD

Bulletin No. 7

SANTA CLARA VALLEY
INVESTIGATION



June, 1955

TD
225
S383.S3
1955
REF
LIBRARY



Courtesy San Jose Chamber of Commerce

Irrigated Orchard in Santa Clara Valley

TD 225 S383531955c.1

SANTA CLARA VALLEY WATER DISTRICT
LIBRARY
5750 ALMADEN EXPRESSWAY
SAN JOSE, CALIFORNIA 95118

STATE OF CALIFORNIA
GOODWIN J. KNIGHT
GOVERNOR

PUBLICATION OF
STATE WATER RESOURCES BOARD

Bulletin No. 7

SANTA CLARA VALLEY
INVESTIGATION



June, 1955

TABLE OF CONTENTS

LETTER OF TRANSMITTAL, STATE WATER RESOURCES BOARD	Page	9
ACKNOWLEDGMENT		10
ORGANIZATION, STATE WATER RESOURCES BOARD		11
ORGANIZATION, STATE DEPARTMENT OF PUBLIC WORKS, DIVISION OF WATER RESOURCES		12
ORGANIZATION, COUNTY OF SANTA CLARA AND CITY OF SAN JOSE		13
CHAPTER I. INTRODUCTION	Page	
Authorization for Investigation	15	
Related Investigations and Reports	15	
Scope of Investigation and Report	16	
Area Under Investigation	17	
Natural Features	17	
Drainage Basins	19	
Climate	20	
Geology	20	
Soils	20	
Present Development	20	
CHAPTER II. WATER SUPPLY	23	
Precipitation	23	
Precipitation Stations and Records	23	
Precipitation Characteristics	25	
Quantity of Precipitation	27	
Runoff	27	
Stream Gaging Stations and Records	27	
Runoff Characteristics	27	
Quantity of Runoff	29	
Imported and Exported Water	30	
Underground Hydrology	30	
Ground Water Geology	31	
Ground Water Basins	32	
Specific Yield and Ground Water Storage		
Capacity	33	
Ground Water Levels	33	
Change in Ground Water Storage	35	
Land Subsidence	36	
Subsurface Inflow and Outflow	37	
High Water Table Areas	38	
Safe Ground Water Yield	39	
Forebay Zones	39	
Pressure Zones	40	
Quality of Water	41	
Standards of Quality for Water	42	
Quality of Surface Water	43	
Quality of Ground Water	43	
CHAPTER III. WATER UTILIZATION AND SUPPLEMENTAL REQUIREMENTS	47	
Water Utilization	47	
Present Water Supply Development	48	
Appropriation of Water	51	
Dams Under State Supervision	51	
Land Use	53	
Past and Present Patterns of Land Use	53	
Probable Ultimate Land Use	53	
Unit Use of Water	55	
Past and Present Water Requirements	57	
Probable Ultimate Water Requirement	58	
Nonconsumptive Water Requirements	59	
Flood Control	59	
Recreation and Fish and Wildlife	61	
Factors of Water Demand	61	
Irrigation Efficiency	61	
Monthly Demands for Water	61	
Permissible Deficiencies in Application of Water	62	
Supplemental Water Requirements	62	
Present Supplemental Water Requirement	62	
Probable Ultimate Supplemental Water Requirement	63	
CHAPTER IV. PLANS FOR WATER DEVELOPMENT	65	
The California Water Plan	65	
Feather River Project	66	
Other Plans Under Consideration	67	
Plans for Initial Local Development	68	
North Santa Clara Valley	68	
Northern Valley Project	69	
(1) Coyote Valley Well Field and Coyote Valley-San Jose Pipe Line	73	
(2) Calero-Los Gatos Conduit	73	
Little Francis Project	74	
Zayante Project	77	
Discussion of Plans for Initial Local Development for North Santa Clara Valley	79	
South Santa Clara Valley	79	
Uvas and Llagas Creeks Project	79	
CHAPTER V. SUMMARY OF CONCLUSIONS, AND RECOMMENDATIONS	85	
Summary of Conclusions	85	
Recommendations	86	

TABLE OF CONTENTS—Continued

APPENDIXES

	Page		Page
A. Agreements Authorizing Investigation and Report	87	G. Records of Partial Mineral Analyses of Ground Water in Santa Clara Valley	113
B. Bibliography of Prior Reports	93	H. Applications to Appropriate Water in Santa Clara Valley	121
C. Geology of the Santa Clara Valley	97	I. Dams Under State Supervision in and Adjacent to Santa Clara Valley, 1954	127
D. Records of Monthly Precipitation in Santa Clara Valley not Previously Published	107	J. Records of Application of Ground Water to Representative Crops in Santa Clara Valley	131
E. Records of Daily Runoff in Santa Clara Valley not Previously Published	109	K. Seasonal Summaries of Monthly Yield Studies	139
F. Records of Depth to Ground Water at Selected Wells in Santa Clara Valley	111	L. Estimates of Cost	145

TABLES

Number	Page	Number	Page
1. Mean, Maximum, and Minimum Seasonal Precipitation at Selected Stations in or Near Santa Clara Valley	24	16. Estimated Subsurface Flow From Coyote Creek Cone to South Santa Clara Valley	38
2. Recorded Seasonal Precipitation at San Jose and Gilroy	26	17. Estimated Average Seasonal Subsurface Inflow From Adjacent Hills in North and South Santa Clara Valleys During Respective Base Periods	38
3. Mean Monthly Distribution of Precipitation at San Jose and Gilroy	26	18. Estimated Safe Mean Seasonal Ground Water Yield of Forebay Zones of Santa Clara Valley	40
4. Estimated Weighted Seasonal Depth and Total Quantity of Precipitation on Santa Clara Valley	27	19. Complete Mineral Analyses of Representative Surface Waters in Santa Clara Valley	44
5. Stream Gaging Stations in Santa Clara Valley	28	20. Complete Mineral Analyses of Ground Waters in Santa Clara Valley	45
6. Recorded and Estimated Seasonal Natural Runoff of Coyote Creek Near Madrone and Uvas Creek Near Morgan Hill	29	21. Ground Water Pumpage by Public Utilities Furnishing Domestic and Industrial Water in Santa Clara Valley	48
7. Estimated Seasonal Natural Flow of Streams Tributary to Santa Clara Valley	30	22. Ground Water Pumpage by Publicly Owned Systems in Santa Clara Valley	48
8. Estimated Mean Monthly Distribution of Natural Flow of Coyote Creek Near Madrone and Uvas Creek Near Morgan Hill	30	23. Areas Served by Water Districts and Mutual Water Companies in Santa Clara Valley	48
9. Estimated Seasonal Surface Inflow to and Outflow From Forebay Zones of Santa Clara Valley	31	24. Irrigated Lands in North and South Santa Clara Valleys, 1947-48	49
10. Seasonal Importation of Water to North Santa Clara Valley, 1935-36 Through 1947-48	31	25. Pattern of Land Use in North and South Santa Clara Valleys, 1948-49	53
11. Estimated Specific Yield and Ground Water Storage Capacity, Santa Clara Valley	34	26. Summary of Average Pattern of Land Use During Base Periods in North and South Santa Clara Valleys	54
12. Measured Fall Depths to Ground Water at Representative Wells in Santa Clara Valley	35	27. Pattern of Urban Land Use in North Santa Clara Valley Under Probable Ultimate Development	54
13. Estimated Average Fall Depths to Ground Water in Forebay Zones of Santa Clara Valley	36	28. Estimated Probable Ultimate Pattern of Land Use in North and South Santa Clara Valleys	54
14. Estimated Weighted Average Seasonal Changes in Fall Ground Water Elevations in Forebay Zones of Santa Clara Valley	36	29. Estimated Unit Values of Mean Seasonal Consumptive Use of Water in Forebay Zones of North and South Santa Clara Valleys	56
15. Estimated Weighted Average Seasonal Changes in Ground Water Storage in Forebay Zones of Santa Clara Valley	36	30. Estimated Weighted Mean Seasonal Application of Ground Water to Principal Crops in Santa Clara Valley	56

TABLE OF CONTENTS—Continued

TABLES—Continued

Number	Page	Number	Page
31. Estimated Present Unit Values of Urban Draft on Ground Water in Santa Clara Valley	57	38. Estimated Average Monthly Distribution of Seasonal Demands for Water in Santa Clara Valley	62
32. Estimated Past and Present Seasonal Water Requirements Met From Forebay Zone of North Santa Clara Valley	57	39. Probable Ultimate Mean Seasonal Supplemental Water Requirements in Santa Clara Valley	63
33. Estimated Past and Present Seasonal Water Requirements Met From Forebay Zone of South Santa Clara Valley	58	40. Estimated New Mean Seasonal Yield From Northern Valley Project	70
34. Estimated Average and Mean Seasonal Draft on Ground Water in North Santa Clara Valley	58	41. Estimated Percolation Rates in Streams of North Santa Clara Valley	71
35. Estimated Average and Mean Seasonal Draft on Ground Water in South Santa Clara Valley	58	42. General Features of Coyote Valley Well Field and Coyote Valley-San Jose Pipe Line	73
36. Probable Ultimate Mean Seasonal Water Requirement in North Santa Clara Valley	59	43. General Features of Calero-Los Gatos Conduit	74
37. Probable Ultimate Mean Seasonal Water Requirement in South Santa Clara Valley	59	44. Areas and Capacities of Little Francis Reservoir	75
		45. General Features of Little Francis Project	77
		46. Areas and Capacities of Zayante Reservoir	77
		47. General Features of Zayante Project	78
		48. Areas and Capacities of Uvas Reservoir	81
		49. General Features of Uvas and Llagas Creeks Project	82

PLATES

Plates Nos. 1-23 follow page 86

Plate No.	Plate No.
1. Hydrologic Zones and Organized Water Conservation Districts, 1954	13. Lines of Equal Change in Ground Water Elevations in North Santa Clara Valley, Fall of 1935 to Fall of 1948
2. Lines of Equal Mean Seasonal Precipitation, 1898-1947	14. Lines of Equal Subsidence of Ground Surface in North Santa Clara Valley for the Periods 1934-1948 and 1948-1954
3. Recorded Seasonal Precipitation at San Jose and Gilroy	15. Lines of Equal Elevation of Ground Water in North Santa Clara Valley, September-October, 1953
4. Accumulated Departure From Mean Seasonal Precipitation at San Jose and Gilroy	16. Land Use, 1955
5. Recorded and Estimated Seasonal Natural Runoff of Coyote Creek Near Madrone and Uvas Creek Near Morgan Hill	17. Existing Water Conservation Works and Works Considered for Future Development, 1955
6. Accumulated Departure From Mean Seasonal Natural Runoff of Coyote Creek Near Madrone and Uvas Creek Near Morgan Hill	18. The Alameda-Santa Clara-San Benito Branch of the Feather River Project Aqueduct, 1955
7. Lines of Equal Depth to Ground Water, Fall of 1953	19. Coyote Valley Well Field and Coyote Valley-San Jose Pipe Line, 1955
8. Diagrammatic Profiles of Pressure and Forebay Zones in North and South Santa Clara Valleys	20. Calero-Los Gatos Creek Conduit, 1955
9. Lines of Equal Elevation of Ground Water, Fall of 1953	21. Little Francis Project, 1955
10. Measured Depth to Water Level at Selected Wells	22. Zayante Project, 1955
11. Average Fall Depth to Ground Water in Forebay Zones	23. Uvas and Llagas Creeks Project, 1955
12. Lines of Equal Change in Ground Water Elevations, Fall of 1948 to Fall of 1953	

Plates Listed Below Follow Appendix C

- C-1 Areal Geology, 1955
- C-2 Index Map
- C-3 Columnar Sections—Santa Clara County
- C-4 Geologic Sections, 1955

TABLE OF CONTENTS—Continued

ILLUSTRATIONS

	Page		Page
Irrigated Orchard in Santa Clara Valley -----	Frontispiece	Anderson Reservoir on Coyote Creek-----	60
Aerial View of Portion of North Santa Clara Valley -----	18	Anderson Dam on Coyote Creek-----	60
Calero Dam and Reservoir on Arroyo Calero-----	50	Lexington Dam and Reservoir on Los Gatos Creek -----	72
Sprinkler Irrigation in Santa Clara Valley---	52	Chesbro Dam on Llagas Creek, May 26, 1955--	80
Orchards in Bloom, Santa Clara Valley-----	52	Gilroy Water Works Dam at Uvas Dam Site on Uvas Creek -----	80

LETTER OF TRANSMITTAL

GOODWIN J. KNIGHT
GOVERNOR



STATE OF CALIFORNIA
STATE WATER RESOURCES BOARD
PUBLIC WORKS BUILDING
SACRAMENTO 5, CALIFORNIA

CLAIR A. HILL, CHAIRMAN, REDDING
R. V. MEIKLE, VICE CHAIRMAN, TURLOCK
A. D. EDMONSTON, STATE ENGINEER
SECRETARY

June 30, 1955

A. FREW, KING CITY
C. A. GRIFFITH, AZUSA
W. P. RICH, MARYSVILLE
W. PENN ROWE, SAN BERNARDINO
PHIL D. SWING, SAN DIEGO

ADDRESS ALL COMMUNICATIONS TO THE SECRETARY

HONORABLE GOODWIN J. KNIGHT, *Governor, and*
Members of the Legislature of the
State of California

GENTLEMEN: I have the honor to transmit herewith Bulletin No. 7 of the State Water Resources Board, entitled "Santa Clara Valley Investigation," as authorized by Chapter 1514, Statutes of 1945, as amended.

The Santa Clara Valley Investigation was conducted and Bulletin No. 7 was prepared by the Division of Water Resources of the Department of Public Works, under the direction of the State Water Resources Board.

Bulletin No. 7 contains an inventory of the underground and surface water resources of Santa Clara Valley, estimates of present and probable ultimate water utilization, estimates of present and probable ultimate supplemental water requirements, and preliminary plans and cost estimates for water development works.

Very truly yours,

A handwritten signature in cursive script that reads "Clair A. Hill".

Clair A. Hill
Chairman

ACKNOWLEDGMENT

Valuable assistance and data used in the investigation were contributed by agencies of the Federal Government, cities, Santa Clara County, public districts, and by private companies and individuals. This cooperation is gratefully acknowledged.

Special mention is also made of the helpful cooperation of the Board of Supervisors of the County of Santa Clara, the Santa Clara County Planning Commission, the City Council of the City of San Jose, the Santa Clara Valley Water Conservation District, the South Santa Clara Water Conservation District, the San Jose Water Works, the Geological Survey, United States Department of the Interior, Stanford University, the Coast Counties Gas and Electric Company, the Pacific Gas and Electric Company, and Blackie and Wood, Consulting Engineers.

ORGANIZATION

STATE WATER RESOURCES BOARD

CLAIR A. HILL, *Chairman*, Redding

R. V. MEIKLE, *Vice Chairman*, Turlock

A. FREW, King City

W. PENN ROWE, San Bernardino

C. A. GRIFFITH, Azusa

PHIL D. SWING, San Diego

W. P. RICH, Marysville

A. D. EDMONSTON, *State Engineer*
Secretary and Engineer

SAM R. LEEDOM, *Administrative Assistant*

ORGANIZATION

STATE DEPARTMENT OF PUBLIC WORKS

DIVISION OF WATER RESOURCES

FRANK B. DURKEE	Director of Public Works
A. D. EDMONSTON	State Engineer
T. B. WADDELL	Assistant State Engineer *

*This bulletin was prepared under
the direction of*

W. L. BERRY
Principal Hydraulic Engineer

by

J. M. HALEY
Supervising Hydraulic Engineer

and

D. F. DRESSELHAUS	Senior Hydraulic Engineer
R. R. REYNOLDS	Senior Hydraulic Engineer
W. B. SHAW	Associate Hydraulic Engineer
R. G. THOMAS	Associate Engineering Geologist
J. W. McPARTLAND	Assistant Hydraulic Engineer
T. P. WOOTTON	Assistant Hydraulic Engineer

Assistance was furnished by

W. MacROSTIE	Supervising Hydraulic Engineer
M. THIEBAUD	Supervising Hydraulic Engineer
A. J. DOLCINI	Senior Hydraulic Engineer
M. G. FAIRCHILD	Senior Hydraulic Engineer
R. T. BEAN	Senior Engineering Geologist
C. F. KLEINE	Associate Hydraulic Engineer
J. H. LAWRENCE	Associate Soil Technologist
H. E. ANDRUS	Photogrammetrist II
J. E. EATON	Assistant Hydraulic Engineer
J. B. YORK	Assistant Civil Engineer
J. D. GOODRIDGE	Junior Civil Engineer
G. E. JOHNSON	Junior Engineering Aid
J. J. DONAHUE	Under Engineering Aid
E. W. FAUSSET	Student Engineering Aid
J. L. JAMES	Supervisor of Drafting Services
LENORE N. CASE	Senior Stenographer-Clerk

*Ground water phases of this bulletin were reviewed
by a staff committee composed of*

H. O. BANKS	Assistant State Engineer
I. M. INGERSON	Principal Hydraulic Engineer
G. B. GLEASON	Supervising Hydraulic Engineer
E. C. MARLIAVE	Supervising Engineering Geologist

HENRY HOLSINGER, Principal Attorney
T. R. MERRYWEATHER, Administrative Officer
ISABEL C. NESSLER, Coordinator of Reports

* P. H. VAN ETEN, Assistant State Engineer, until June 15, 1951.

ORGANIZATION

COUNTY OF SANTA CLARA BOARD OF SUPERVISORS

ARTHUR W. BROWN, *Chairman*

WALTER CASPER
ED. LEVIN

SAM DELLA MAGGORI
JOSEPH M. McKINNON

E. T. McGEHEE, *County Clerk*
HOWARD CAMPEN, *County Counsel*
LEONARD BUSHNELL, *County Surveyor*

CITY OF SAN JOSE

PARKER L. HATHAWAY, *Mayor*
ANTHONY P. HAMANN, *City Manager*

COUNCILMEN

ROBERT DOERR
WILLIAM J. FOLEY
JOE SANTORA

LOUIS S. SOLARI
GEORGE STARBIRD
FRED WATSON

DOROTHY COVILL, *City Clerk*
ROBERT E. CASSIN, *City Attorney*
H. J. FLANNERY, *City Engineer*

CHAPTER I

INTRODUCTION

The area in Santa Clara County under this investigation has in recent years experienced an increase in water utilization, and as a result is confronted with a need for more complete conservation of its local water resources, as well as for the consideration of importation of supplemental supplies. Water demands have increased substantially in the Santa Clara Valley, keeping pace with the growth and development of the area. Although some water for early agricultural and urban developments was diverted from surface streams, ground water has long been the principal source of supply. Problems related to deficient ground water supplies have been recognized for a number of years and have brought about local concern. These difficulties have been manifested largely in progressive lowering of ground water levels. Public agencies, consulting engineers, and individuals have reported on the problems and have proposed plans for their solution. As a result, a number of important water conservation works have been locally financed and constructed to provide surface storage and to replenish the ground water basins of the Santa Clara Valley.

Despite these steps toward solution of water problems in the Santa Clara Valley, it has become increasingly apparent that additional conservation measures will be required to satisfy present water needs, and to provide for growth in the future. This was clearly emphasized in the decade from 1940 to 1950, when recession of ground water levels was greatly accelerated in most areas of the Santa Clara Valley by increased pumping draft.

AUTHORIZATION FOR INVESTIGATION

In 1947, officials of the County of Santa Clara and of the City of San Jose, concerned about the increasing water problems confronting the area, requested the State Water Resources Board to undertake a cooperative survey of water conditions in the Santa Clara Valley. The Secretary of the Santa Clara County Planning Commission appeared before the Board on December 5, 1947, representing local interests in this matter. The Board referred the request to the State Engineer for preliminary examination and report on the need for such an investigation, and an estimate of its scope, duration, and cost.

The State Water Resources Board on January 16, 1948, approved a recommendation by the State Engineer, based on findings of the preliminary examination, for a cooperative investigation, and authorized

negotiation of an agreement with local agencies. An agreement between the State Water Resources Board, the County of Santa Clara, the City of San Jose, and the Department of Public Works, acting through the agency of the State Engineer, was executed on April 1, 1948. This agreement provided that the work to be performed shall "consist of investigation and report on the underground water supply in the County of Santa Clara, including quality, replenishment and utilization thereof, and, if possible, a method or methods of solving the water problems involved." This agreement authorized the provision of funds to meet the costs of investigation for one year. A supplemental agreement executed by the same parties on February 18, 1949, authorized funds to complete the investigation and bulletin.

Funds to meet the costs of the investigation and bulletin to the extent of \$44,000 were provided as follows: State of California (State Water Resources Board), \$22,000; City of San Jose, \$11,000; and County of Santa Clara, \$11,000. Additional funds have been expended in investigation of the Santa Clara Valley by the State Water Resources Board in connection with the current State-wide Water Resources Investigation, certain results of which have been used in connection with the Santa Clara Valley Investigation.

Copies of the two agreements between the State Water Resources Board, the County of Santa Clara, the City of San Jose, and the Department of Public Works are included as Appendix A.

RELATED INVESTIGATIONS AND REPORTS

Reports on prior investigations, containing information pertinent to the evaluation of water problems in the Santa Clara Valley have been reviewed in connection with the current investigation. These reports, listed in Appendix B, cover most phases of the water problems in the Santa Clara Valley. State Division of Water Resources Bulletin No. 42, published in 1933, reported on historic ground water level recession in northern Santa Clara Valley, the amount of ground water depletion so represented, and the quantity of replenishment from surface streams tributary to the northern part of the valley. Similar information, as well as geologic details, specific yield of the alluvium, and quality of water are included in reports by the United States Geological Survey, and in reports by consulting engineers. Ground water pollution by seawater intrusion, and ground surface subsidence, have

been discussed in a technical paper by C. F. Tolman and J. F. Poland, and published in the July, 1940, Transactions of the American Geophysical Union. The United States Department of Agriculture and the University of California have published reports dealing with the soils of the area. Investigation of water problems, and designs of reservoirs and percolation works for their solution have been reported on by consulting engineers.

The Division of Water Resources is presently conducting surveys and studies as a part of the State-wide Water Resources Investigation, authorized by Chapter 1541, Statutes of 1947. This investigation, under direction of the State Water Resources Board, has as its objective the formulation of The California Water Plan, for full conservation, control, protection, and utilization of the State's water resources, to meet present and future water needs for all beneficial purposes and uses in all parts of the State, insofar as practicable. Surveys and studies were conducted by the Division of Water Resources for the Water Project Authority in connection with the proposed Feather River Project which was described in detail in a publication of the State Water Resources Board, entitled "Report on Feasibility of Feather River Project and Sacramento-San Joaquin Delta Diversion Projects Proposed as Features of The California Water Plan," dated May, 1951, and which was authorized and adopted by the 1951 Legislature. Results of these investigations have a direct bearing on solutions to the water problems of the Santa Clara Valley, particularly with regard to plans to meet supplemental water requirements of the area under ultimate conditions of development. These investigations are described in a publication of the Division of Water Resources, entitled "Program for Financing and Constructing the Feather River Project as the Initial Unit of The California Water Plan," dated February, 1955.

SCOPE OF INVESTIGATION AND REPORT

It has been stated that under provisions of the authorizing agreements the general objectives of the Santa Clara Valley Investigation included investigation and study of the underground water supply of lands in the investigational area, including quality, replenishment and utilization thereof, and, if possible, a method or methods of solving the water problems involved. In attaining these objectives it was necessary that the scope of the investigation include full consideration of surface as well as ground water supplies, and that it involve determination of present and ultimate water utilization and supplemental water requirements.

The area of comprehensive investigation was generally limited to valley floor lands underlain by ground water in the County of Santa Clara, and

encompassed about 217,000 acres. However, certain areas outside and adjacent to the valley floor were considered in determination of probable ultimate water requirements, and conservation works extending beyond the boundaries of Santa Clara County were included in the surveys and studies. Since minor underground water supplies lying outside the floor of Santa Clara Valley were not studied, the investigation was not county-wide in its scope.

Field work in the investigational area, and office studies, as authorized by the initial and supplemental cooperative agreements, commenced in March, 1948, and continued into 1954.

In the course of the investigation, available precipitation and stream flow records were collected and compiled, in order to evaluate water supplies available to the investigational area. Four new stream gaging stations were installed and maintained to supplement the available hydrographic data. These stations were on Little Arthur Creek near Adams School, Bodfish Creek near Gilroy, Llagas Creek at Pacheco Pass Road, and Carnadero Creek at Bloomfield Avenue.

In order to determine ground water storage capacity and yield, and to assist in the determination of areas of free and confined ground water, geologic features of the ground water basin underlying the investigational area were investigated. This study included the collection and study of about 1,100 well logs throughout the area. A geologic report on Santa Clara Valley is included as Appendix C to this bulletin.

The effects of draft on and replenishment of the ground water basin were determined from measurements of static ground water levels made at about 800 wells each spring and fall during the period of investigation. These wells formed a comprehensive measuring grid over the entire area. In addition, measurements to determine monthly fluctuations of water levels were made at approximately 100 control wells.

Present land use was determined by a complete survey of all lands in the investigational area. This study was conducted in 1948 and 1949. The total area surveyed was about 217,000 acres. The land use survey data were used in conjunction with available data on unit water use to estimate total present water utilization in the investigational area.

Current irrigation practices in the investigational area were surveyed in order to determine unit application of water to important crops on lands of various soil types. During the 1948 irrigation season, records of application of water were collected at 110 plots, and during the following season at 42 plots. The data collected included records of pump discharge, acreage served, crops irrigated, number and period of irrigations, and amount of water applied.

Studies were made of the mineral quality of surface and ground waters, in order to evaluate their suitability for irrigation and municipal use, and to determine the cause of degradation in mineral quality in local areas during recent years. Data used in these studies included some 783 partial and 59 complete mineral analyses of ground water from wells. Analyses of surface water samples were 19 in number.

Field reconnaissance surveys, including geologic examinations, were made to locate and evaluate possible dam and reservoir sites for conservation of surface runoff. Reconnaissance surveys were also made of possible routes for conveyance of water to areas of use. For the more favorable and strategically located sites, topographic surveys were made and maps prepared or obtained from other sources.

Results of the Santa Clara Valley Investigation are presented in this bulletin in the four ensuing chapters. Chapter II, "Water Supply," contains evaluations of precipitation, surface and subsurface inflow and outflow, and imports of water. It also includes results of investigation and study of the ground water basins, and contains data regarding mineral quality of surface and ground water supplies. Chapter III, "Water Utilization and Supplemental Requirements," includes data and estimates of present and probable ultimate land use and water utilization, and contains estimates of present and probable ultimate supplemental water requirements. It also includes available data on factors of water demand, with respect to rates, times, and places of delivery. Chapter IV, "Plans for Water Development," describes preliminary plans for conservation and utilization of available water supplies to meet supplemental water requirements, including operation and yield studies, design considerations and criteria, and cost estimates. Chapter V, "Summary of Conclusions, and Recommendations," comprises a summary statement of conclusions resulting from the investigation and studies, together with recommendations for action relating to solution of water problems.

AREA UNDER INVESTIGATION

The Santa Clara Valley is an intermediate valley in the Coastal Range, between the Santa Cruz Mountains and the Gabilan Range on the west and the Diablo Range on the east. The valley extends in a southeasterly direction from San Francisco Bay to near Hollister.

The portion of the Santa Clara Valley under investigation, and to which all subsequent reference is limited, lies entirely in Santa Clara County, and extends from San Francisco Bay to the Pajaro River, a distance of about 50 miles. The valley varies in width from about fourteen miles in the northern portion to less than a mile near the midpoint, and to approximately five miles in the southern portion.

Most of the cultivated land in Santa Clara County is contained within the Santa Clara Valley.

The Santa Clara Valley is separated into two main drainage areas by a low divide in the alluvium near Morgan Hill, about 25 miles south of the northern boundary of the area of investigation. For purposes of this bulletin, the portion lying north of the divide, with drainage into San Francisco Bay, is designated "North Santa Clara Valley," and the remaining portion with drainage south to the Pajaro River is called "South Santa Clara Valley." The location of the area of investigation is indicated on Plate 1, entitled "Hydrologic Zones and Organized Water Conservation Districts, 1954." For purposes of hydrologic analysis, North and South Santa Clara Valleys were further divided into zones comprising in each valley a "Forebay Zone" and a "Pressure Zone." These subdivisions are shown on Plate 1.

Natural Features

The Santa Clara Valley occupies an elongated trough between the Diablo Range on the east and the Santa Cruz Mountains on the west. The valley and each of these ranges trend in southeast and northwest directions. Owing to ample precipitation, native vegetation in the Santa Cruz Mountains is dense, ranging from redwoods, firs, oaks, and other typically associated trees, to chaparral on the higher ridges. Lesser amounts of precipitation in the Diablo Range result in less timber growth than in the Santa Cruz Mountains. A moderate to heavy growth of wild grasses is found in the Diablo Range. Climatically, the lower reaches of the Santa Cruz Mountains lying adjacent to the floor of the valley are attractive for residential purposes, and for agriculture where soils and topography are favorable. Virtually all of the highly developed agricultural lands, however, lie on the valley floor.

The east slope of the Santa Cruz Mountains tributary to the Santa Clara Valley is relatively narrow, and somewhat steeper than its western slope. Width of the east slope varies from a minimum of about three miles to a maximum of approximately eight miles. The highest point reached in this portion of the Santa Cruz Mountains is Loma Prieta, with an elevation of 3,798 feet, about 11 miles west of Morgan Hill.

The Diablo Range, paralleling the Santa Clara Valley on the east, varies in width from 20 miles opposite the northern portion of the valley, to about 10 miles opposite San Martin, and to about 17 miles at the southern extremity of South Santa Clara Valley. A substantial portion of the Diablo Range in Santa Clara County is within the Alameda Creek drainage area and, therefore, is not tributary to the Santa Clara Valley. Another part of the Diablo Range, lying in southeastern Santa Clara County, drains to Pacheco Creek, then to the Pajaro River,



Courtesy State Division of Highways

Aerial View of Portion of North Santa Clara Valley

and thence to Monterey Bay. The remainder of the Diablo Range in Santa Clara County drains westerly to the area under investigation. Copernicus Peak, with an elevation of 4,372 feet, and Mount Isabel, with an elevation of 4,223 feet, are the highest points on the Diablo Range in Santa Clara County.

The portion of the Santa Clara Valley under investigation has an irregular outline, defined on the northwest by tidelands along the shore of San Francisco Bay, on the southeast by the Pajaro River, and on the southwest and northeast by foothills of the Santa Cruz Mountains and Diablo Range, respectively. Alluvial fans emanating from these foothills slope toward the central part of the valley, with gradients ranging from 500 to 20 feet per mile. The general slope of North Santa Clara Valley is in a northwesterly direction, and varies from 25 feet per mile near Morgan Hill to about 5 feet per mile near San Francisco Bay. South Santa Clara Valley slopes in a southerly direction, with an average gradient of approximately 15 feet per mile.

Several low bedrock hills rise from the floor of North Santa Clara Valley from four to six miles southeast of the City of San Jose. Other rock masses protrude from the alluvium two to five miles northwest of Gilroy, in South Santa Clara Valley. Aside from these features, the surface of the valley floor has few notable irregularities.

Drainage Basins

Streams tributary to the Santa Clara Valley are typical of those draining the Coast Range in the central part of California. By far the greater portion of runoff occurs after storms during the winter months. Although some streams continue to flow in the mountains during the summer, most are dry during this season on the valley floor, except where replenished by effluent seepage from ground water or return water from irrigation.

The stream system of North Santa Clara Valley consists of the Coyote Creek and Guadalupe River groups, and of Stevens, Permanente, San Antonio, Matadero, and San Francisquito Creeks. Coyote Creek originates in the Diablo Range east of the Santa Clara Valley. After entering the valley floor area near Morgan Hill, Coyote Creek flows northwesterly near the eastern edge of the valley to The Narrows, seven miles southeast of San Jose. At this point, the stream flows over bedrock at the northwest tip of Edenvale Hills. Below The Narrows the valley broadens, and the Coyote Creek channel runs parallel to and about four miles southwest of the eastern boundary of the valley, discharging into San Francisco Bay near Alviso. Dry and Silver Creeks are tributary to Coyote Creek on the east side of the valley, and join about one mile below Evergreen, flowing northwesterly to the vicinity of Alum Rock, and thence westerly to join Coyote

Creek immediately north of San Jose. Several small streams tributary to Dry Creek drain the east side of the valley between Evergreen and Alum Rock. Farther north, Penitencia Creek, draining the watershed east of Alum Rock, flows southwesterly, joining Coyote Creek north of San Jose. The former channel of Penitencia Creek, paralleling and then joining Coyote Creek near the county line, now carries only local surface runoff and waters of Berryessa Creek, tributary from the east. Scott Creek flows along the northern boundary of the investigational area to join Coyote Creek near San Francisco Bay.

The Guadalupe River group consists of those streams rising on the eastern slope of the Santa Cruz Mountains tributary to the Guadalupe River. Los Alamitos, Guadalupe, and Los Gatos Creeks originate on the northern and northwestern slope of Loma Prieta. Los Alamitos and Guadalupe Creeks join on the valley floor at the northwest extremity of the Santa Teresa Hills, and then, as the Guadalupe River, flow northwesterly through San Jose to San Francisco Bay near Alviso. Los Gatos Creek leaves the Santa Cruz Mountains at Los Gatos, and flows northeasterly about nine miles to join the Guadalupe River in San Jose. Saratoga, San Tomas Aquinas, and Calabazas Creeks enter the valley floor north of Los Gatos, and flow northerly across the valley, joining near Agnew. The combined stream then flows northerly to join the Guadalupe River west of Alviso.

Watercourses draining the eastern slope of the Santa Cruz Mountains north of the Guadalupe River group are, from south to north: Stevens, Permanente, San Antonio, Matadero, and San Francisquito Creeks. San Francisquito Creek and its tributary, Los Trancos, drain the area lying generally southwest of Palo Alto. Their courses coincide with a portion of the northern boundary of the investigational area.

The stream system of South Santa Clara Valley is comprised of Llagas Creek and the Carnadero Creek group, both of which are tributary to the Pajaro River. Llagas Creek originates on the eastern slope of Loma Prieta, flows northeasterly for a short distance, thence southeasterly, flowing onto the valley floor near Morgan Hill. Small streams flowing from the Diablo Range on the eastern side of the valley are tributary to Llagas Creek along its southeasterly course to the Pajaro River.

Tributaries of Carnadero Creek are Uvas, Little Arthur, and Bodfish Creeks, originating on the east slope of the Santa Cruz Mountains. Uvas Creek rises on the southeastern slope of Loma Prieta and flows approximately southeasterly, reaching the valley floor four miles southwest of San Martin. From that point, Uvas Creek flows southerly two miles to the point where Little Arthur Creek enters from the west, thence southeasterly about two miles to its confluence with Bodfish Creek. From that point, as Carnadero

Creek, the combined flow trends generally southeast-erly, but in its final three miles swings southward to join the Pajaro River.

Clim ate

The climate of the Santa Clara Valley is generally mild, and is characterized by dry summers with moderate to high daytime temperatures and cool nights, and wet winters with moderate temperature. More than 80 per cent of the precipitation occurs during the five-month period from November through March. The growing season is long, the 30-year recorded average for San Jose, centrally located in North Santa Clara Valley, being 305 days between killing frosts, and the 11-year recorded average for Gilroy, centrally located in South Santa Clara Valley, being 273 days between killing frosts. Temperatures at San Jose have ranged from 20° F. to 106° F., and the monthly average for the period from 1906 to 1952 ranged from 49.3° F. in January to 67.2° F. in July. Temperatures in Gilroy have ranged from 20° F. to 116° F., and the monthly average for the period from 1874 to 1915 ranged from 46.5° F. in January to 68.8° F. in July.

Geology

The geologic formations of the Santa Clara Valley region may be divided into water-bearing and non-water-bearing series. Nonwater-bearing rocks form the highlands bordering the Santa Clara Valley, and underlie water-bearing sediments of the valley itself. The nonwater-bearing rocks range in age from upper Jurassic to middle Pliocene. Marine sandstones and shales are most common, but conglomerates, cherts, marls, and several varieties of basic igneous rocks also occur.

Structure of the nonwater-bearing rocks is complex, consisting of faults and folds striking generally in a northwesterly direction. The most prominent faults in the region are the San Andreas fault in the Santa Cruz Mountains west of the valley, and the Calaveras-Hayward fault system in the Diablo Range east of the valley, both having a northwesterly trend. Faults in the southern part of Santa Clara County extend between the San Andreas and Calaveras-Hayward fault systems. The Santa Clara Valley is essentially a down-dropped block between the Santa Cruz Mountains and the Diablo Range.

The water-bearing sediments are of Plio-Pleistocene and upper Quaternary age. Plio-Pleistocene sediments outcrop in hills immediately adjacent to the valley floor, and probably underlie most of the upper Quaternary sediments comprising the valley fill. The upper Quaternary sediments, composed of up to 1,000 feet of poorly sorted gravel, sand, and clay, contain most of the ground water in the Santa Clara Valley.

Soils

Soils of the Santa Clara Valley vary in their chemical and physical properties in accordance with differences in parent material, drainage, and age and degree of development since their deposition. The soils may be divided into two broad groups: (1) those derived from recent alluvial depositions, and (2) those derived from old alluvial fans or terraces. The first group may be further divided into alluvial land soils and basin land soils, and the second group may be divided into low terrace land soils and high terrace land soils.

Alluvial fan soils occupy the flood plains immediately adjacent to stream channels generally throughout the valley. They consist of unmodified to slightly modified alluvial deposits, and are usually medium to fine textured, having deep permeable to moderately dense subsoils. These soils are highly productive and suited to a wide variety of crops, and have the highest agricultural value.

Basin land soils occupy large flat basin-like areas in North Santa Clara Valley. In South Santa Clara Valley the basin land soils occupy an area generally adjacent to Llagas Creek and the Pajaro River. Basin land soils are fine textured, and are characterized by dense subsoil, or hardpan, and poor drainage. These soils are best suited for shallow-rooted field crops.

Low terrace land soils are generally found in smooth elevated areas around the edge of the valley. These soils are gravelly to medium textured, having slightly to moderately dense subsoil, and are mostly devoted to nonirrigated orchard crops.

High terrace land soils are smooth to rolling higher areas of alluvial or older valley fill materials. These soils vary from fine to medium textured, with moderately dense to dense clay subsoils, and are not generally suited to irrigation.

Present Development

The Santa Clara Valley derives its name from Mission Santa Clara, founded by the Franciscan padres in 1777 on Guadalupe Creek at the northern edge of the present City of Santa Clara. Following the founding of the Mission, the Pueblo de San Jose de Guadalupe, now San Jose, was established.

Land use in the Santa Clara Valley has developed from nonirrigated pasture and hay lands, through an era of grain growing, to the present period of intensive production of deciduous fruits and truck and row crops. Fruit and vegetable processing and packing plants have expanded with agricultural development.

There has been considerable recent industrial development in the vicinities of San Jose, Sunnyvale, Mountain View, and Milpitas. Favorable climate, increasing markets, and availability of adequate transportation facilities will undoubtedly attract more industry to the area in the future.

World War II brought a large influx of military personnel and civilians to the area. After the end of the war many persons in both groups remained in the county because of the pleasant living conditions. The total population, which had grown from 12,000 in 1860 to 175,000 in 1940, surged to about 291,000 in 1950. In San Jose, the principal city of the Santa Clara Valley, the population expanded from 68,500 in 1940 to an estimated 95,600 in 1950. The majority of people in the Santa Clara Valley live in urban areas. About 55 per cent are residents of large incorporated cities, while many others live in smaller incorporated communities. The rural population represents less than half of the total population.

The principal industries in the area are the canneries and packing plants associated with the processing of agricultural products. Other industries include assembling of automobiles, steel fabrication, chemical and cement production, and manufacture of clothing, electrical equipment, pumps, food machinery, and construction equipment.

Adequate rail, motor truck, and air facilities serve the residential areas, factories, and farms in the

Santa Clara Valley. The main coastal line of the Southern Pacific Railroad from San Francisco to Los Angeles passes through the valley. At San Jose, a branch of this railroad from Oakland joins the main line. The Western Pacific Railroad also provides rail transportation to the valley. Santa Clara County is also served by a large number of trucking concerns, including common carriers and contract haulers.

A survey conducted in 1949 as a part of the current investigation indicated that irrigated lands in the Santa Clara Valley totaled about 130,000 acres, while approximately 35,000 acres were dry-farmed. Of the irrigated acreage, deciduous orchards and vineyards occupied about 72 per cent of the land, truck vegetables approximately 18 per cent, and field crops about 10 per cent. The deciduous orchard lands are devoted chiefly to prunes, apricots, pears, cherries, and walnuts. Approximately one-third of the supply of prunes grown in the world is produced in the Santa Clara Valley. Truck and row crops, including beans, sugar beets, broccoli, cauliflower, celery, lettuce, and tomatoes, are also grown on the valley floor, but are of lesser importance than orchards.

CHAPTER II

WATER SUPPLY

Virtually all surface and ground water supplies in the Santa Clara Valley are derived from precipitation on lands overlying the ground water basin, tributary surface inflow, and subsurface inflow. However, a small amount of water is imported through the water supply system of the City of San Francisco to a portion of North Santa Clara Valley. Percolation of stream flow on the valley floor is an important source of ground water replenishment. Sewage and waste waters from principal urban areas in North Santa Clara Valley are carried to San Francisco Bay. Sewage and waste waters from other communities are disposed of within the area. The water supply of the area is considered and evaluated in this chapter under the general headings "Precipitation," "Runoff," "Imported and Exported Water," "Underground Hydrology," and "Quality of Water."

The following terms are used as defined in connection with the discussion of water supply in this bulletin:

Annual—This refers to the 12-month period from January 1st of a given year through December 31st of the same year, sometimes termed the "calendar year."

Seasonal—This refers to any 12-month period other than the calendar year.

Precipitation Season—The 12-month period from July 1st of a given year through June 30th of the following year.

Runoff Season—The 12-month period from October 1st of a given year through September 30th of the following year.

Investigational Seasons—The two runoff seasons of 1948-49 and 1949-50, during which most of the field work on the Santa Clara Valley Investigation was performed.

Mean Period—A period chosen to represent conditions of water supply and climate over a long series of years.

Base Period—A period chosen for detailed hydrologic analysis because prevailing conditions of water supply and climate were approximately equivalent to mean conditions, and because adequate data for such hydrologic analysis were available.

Mean—This is used in reference to arithmetical averages relating to mean periods.

Average—This is used in reference to arithmetical averages relating to periods other than mean periods.

In studies for the current State-wide Water Resources Investigation, it was determined that the 50 years from 1897-98 through 1946-47 constituted the most satisfactory period for estimating mean seasonal precipitation generally throughout California. Similarly, the 53-year period from 1894-95 through 1946-47 was selected for determining mean seasonal runoff. In studies of the Santa Clara Valley, conditions during these periods were considered representative of mean conditions of water supply and climate.

Studies were made to select base periods for hydrologic analysis of the Santa Clara Valley during which conditions of water supply and climate would approximate mean conditions, and for which adequate data on inflow, outflow, and ground water levels would be available. It was determined that the 13-year period from 1935-36 through 1947-48 was satisfactory in this respect for North Santa Clara Valley. Furthermore, during this period there was only a small change in ground water storage. For like reasons, a base period embracing the 16 years from 1932-33 through 1947-48 was selected for hydrologic analysis in South Santa Clara Valley. Conditions during these chosen base periods closely approached conditions prevailing during the mean period, and were considered to be equivalent. For this reason, determined relationships between base period water supply and present and probable ultimate water utilization were assumed to be equivalent to corresponding relationships which might be expected under mean conditions of water supply and climate.

PRECIPITATION

The Santa Clara Valley lies within the path of storms which periodically sweep inland from the North Pacific during winter months. Rainfall resulting from these storms ranges from moderate to heavy, and direct precipitation provides a substantial portion of the water supply of the area.

Precipitation Stations and Records

Forty-one precipitation stations in or near the Santa Clara Valley have unbroken records of 10 years' duration or longer. These stations are fairly well distributed areally, and their records are suffi-

SANTA CLARA VALLEY INVESTIGATION

TABLE 1
MEAN, MAXIMUM, AND MINIMUM SEASONAL PRECIPITATION AT SELECTED
STATIONS IN OR NEAR SANTA CLARA VALLEY

Map reference number	Station	Elevation, in feet	Period of record	Source of record	Mean seasonal precipitation, in inches of depth	Maximum and minimum seasonal precipitation	
						Season	Inches of depth
SC-1	Almaden Reservoir	640	1936-53**	SCVWCD	29.78*	1951-52 1946-47	50.58 17.70
SC-2	Alviso	8	1941-53**	Private	14.37*	1951-52 1946-47	20.21 9.03
SC-3	Berryessa 1E	255	1921-53**	Private	16.63*	1951-52 1923-24	25.40 7.95
2-90	Campbell	217	1897-27	USWB	14.85*	1906-07 1912-13	23.38 5.29
SC-4	Campbell Water Works	192	1935-53	Private	15.77*	1940-41 1946-47	28.17 10.23
SC-5	Coyote Reservoir	800	1937-53**	SCVWCD	20.57	1940-41 1938-39	34.46 14.28
3-10	Creeside	460	1907-51**	Private	29.43	1913-14 1923-24	55.61 9.61
SC-6	Cupertino Store	215	1896-1953	Private	15.68	1940-41 1912-13	31.46 5.82
3-11	Cushing Ranch	375	1928-49	Private	30.21*	1940-41 1930-31	49.60 14.56
SC-7	Deciduous Fruit Field Station	135	1935-53	UC	15.08*	1940-41 1938-39	26.50 8.63
SC-8	Evergreen	340	1942-53	Private	16.16*	1951-52 1946-47	24.09 10.00
3-14	Gilroy	193	1874-1915	USWB	19.10*	1889-90 1876-77	37.75 6.53
3-13	Gilroy, Wentz	204	1873-1953	Private	19.92	1889-90 1876-77	48.04 7.66
SC-9	Gilroy, 6W	355	1937-49	Private	28.58*	1940-41 1938-39	50.50 17.76
SC-10	Guadalupe Reservoir	450	1936-53**	SCVWCD	27.55*	1940-41 1946-47	43.94 16.30
2-86	Howell Reservoir (Lake Kittredge)	1,400	1915-53	SJWWKS	40.05*	1940-41 1923-24	71.38 14.94
2-84	Lake Ranch Reservoir (Lake McKenzie)	1,809	1926-53	SJWWKS	43.83*	1940-41 1938-39	74.48 25.09
2-80	Lick Observatory (Mt. Hamilton)	4,209	1881-1953	USWB	27.31	1883-84 1923-24	58.09 11.56
3-0111	Little Uvas	625	1929-39** 1943-50	Private	34.22*	1937-38 1932-33	63.87 21.00
SC-11	Llagas Creek	620	1931-50	Private	25.58*	1937-38 1932-33	46.91 12.65
2-88	Los Gatos	500	1885-1953	USWB	28.94	1889-90 1923-24	67.22 11.41
2-89	Los Gatos Reservoir	560	1915-53	SJWWKS	28.68*	1940-41 1923-24	53.14 11.11
2-92	Los Gatos Summit	1,800	1922-38	Private	43.57*	1937-38 1923-24	67.50 14.45
2-87	Madera Colorado (Montevina Road Reservoir)	696	1915-53	SJWWKS	31.86*	1951-52 1923-24	54.51 11.78
2-60	Main Station	91	1914-53	SJWWKS	13.61*	1914-15 1923-24	22.67 6.24

TABLE 1—Continued
 MEAN, MAXIMUM, AND MINIMUM SEASONAL PRECIPITATION AT SELECTED
 STATIONS IN OR NEAR SANTA CLARA VALLEY

Map reference number	Station	Elevation, in feet	Period of record	Source of record	Mean seasonal precipitation, in inches of depth	Maximum and minimum seasonal precipitation	
						Season	Inches of depth
2-74	Mountain View	79	1885-1953	Private	14.21	1889-90 1912-13	31.15 6.04
3-12	Morgan Hill, Edes	392	1924-38	Private	19.90*	1937-38 1930-31	34.55 11.70
2-71	Palo Alto	57	1910-53	USWB	15.93*	1914-15 1923-24	26.64 7.06
SC-12	Paradise Valley	425	1897-1953	Private	24.09	1913-14 1923-24	46.76 8.45
SC-13	Peabody Ranch	500	1931-53	Private	17.96*	1940-41 1933-34	32.12 11.19
SC-14	Pueblo Reservoir (Miguelito Reservoir)	470	1929-53	SJWWKS	16.57*	1951-52 1946-47	23.58 10.33
2-78	San Jose	141	1874-1953	USWB	13.72	1889-90 1876-77	30.30 4.83
2-76	Santa Clara	90	1881-1953	USWB	14.86	1889-90 1912-13	31.23 6.57
2-85	Saratoga Reservoir (Big Basin Way)	577	1915-53	SJWWKS	31.46*	1940-41 1923-24	55.48 11.01
2-91	Seven Mile Reservoir	322	1915-53	SJWWKS	19.79*	1940-41 1923-24	33.71 7.01
2-72	Stanford Corporation Yard	118	1930-53	Stan. Univ.	16.81*	1940-41 1930-31	27.99 9.36
SC-15	Stevens Creek Reservoir	600	1937-53**	SCVWCD	24.60*	1951-52 1946-47	44.95 15.64
2-75	Sunnyvale	97	1926-42	USWB	14.76*	1940-41 1928-29	27.24 8.63
2-94	Williams Reservoir (Wrights Station)	1,222 (900)	1912-53**	SJWWKS	43.79*	1937-38 1917-18	73.96 19.32
SC-16	Willow Glen	135	1933-53	Private	15.32*	1940-41 1949-50	24.50 9.52
2-93	Wrights	1,600	1918-53	USWB	49.43*	1920-21 1923-24	84.43 16.75

* Estimated.

** Broken record.

SCVWCD—Santa Clara Valley Water Conservation District.
SJWWKS—San Jose Water Works.

Stan. Univ.—Stanford University.

USWB—United States Weather Bureau.

UC—University of California.

cient to provide an adequate representation of the pattern of precipitation. Most of the records of precipitation of these stations have been published in bulletins of the United States Weather Bureau. Unpublished records were obtained from local agencies and individuals, and are included in Appendix D. Locations of the stations are shown on Plate 2, entitled "Lines of Equal Mean Seasonal Precipitation, 1898-1947." The stations and map reference numbers are listed in Table 1, together with elevations of the stations, periods and sources of record, and mean, maximum, and minimum seasonal precipitation. The map reference numbers for twenty-five of the stations correspond to those utilized in State Water Resources Board Bulletin No. 1, "Water Resources of Cali-

fornia." New map reference numbers were assigned to the remaining stations listed and are designated by the prefix "SC." In those instances where it was necessary, the available records were extended to cover the 50-year mean period by comparison with records of nearby stations having records covering this period.

Precipitation Characteristics

Because of the uniformity of the general precipitation in North Santa Clara Valley and South Santa Clara Valley, as indicated on Plate 2, precipitation at San Jose and Gilroy was considered to be fairly representative of rainfall over each of the two sub-areas, respectively. A record of precipitation at San

Jose was available from a United States Weather Bureau station maintained since 1874-75, and a record of precipitation at Gilroy since 1873-74 was available from Mr. Carrol Wentz of Gilroy. Recorded seasonal precipitation at these two stations during the periods of record are given in Table 2, and are shown on Plate 3, entitled "Recorded Seasonal Precipitation at San Jose and Gilroy."

Precipitation in the Santa Clara Valley occurs almost entirely as rainfall, although snow occasionally occurs on the higher surrounding mountains.

TABLE 2
RECORDED SEASONAL PRECIPITATION AT
SAN JOSE AND GILROY
(In inches of depth)

Season	San Jose	Gilroy	Season	San Jose	Gilroy
1873-74	-----	24.17	1913-14	19.45	34.71
74-75	7.90	20.19	14-15	22.71	26.22
75-76	19.48	32.79	15-16	16.31	23.96
76-77	4.83	7.66	16-17	12.63	21.88
77-78	19.28	29.43	17-18	9.36	10.28
78-79	16.40	17.90	18-19	18.87	22.33
1879-80	13.80	23.73	1919-20	8.81	14.81
80-81	12.45	24.44	20-21	15.02	18.92
81-82	11.75	14.98	21-22	14.77	22.82
82-83	11.39	16.10	22-23	13.85	18.73
83-84	20.08	26.12	23-24	6.55	7.91
1884-85	11.27	15.75	1924-25	14.24	16.90
85-86	20.63	23.68	25-26	14.47	14.24
86-87	11.36	11.85	26-27	13.88	22.71
87-88	12.17	17.63	27-28	10.11	15.97
88-89	15.71	15.47	28-29	10.14	12.96
1889-90	30.30	48.04	1929-30	10.83	15.70
90-91	12.88	17.50	30-31	8.36	12.29
91-92	16.51	15.22	31-32	13.40	24.59
92-93	25.17	28.89	32-33	8.89	13.61
93-94	12.92	12.28	33-34	8.75	12.13
1894-95	23.32	27.67	1934-35	16.18	21.38
95-96	13.69	19.87	35-36	12.41	21.44
96-97	16.56	19.70	36-37	16.93	25.56
97-98	6.87	9.92	37-38	18.57	31.39
98-99	10.02	19.85	38-39	10.67	12.15
1899-1900	13.87	15.96	1939-40	16.45	24.21
00-01	19.88	24.72	40-41	21.42	34.85
01-02	12.98	19.02	41-42	16.50	23.34
02-03	13.89	18.73	42-43	13.20	20.84
03-04	10.47	19.41	43-44	11.47	19.49
1904-05	17.96	24.93	1944-45	12.43	22.02
05-06	15.09	32.51	45-46	11.23	18.13
06-07	22.71	30.38	46-47	9.04	15.94
07-08	11.96	13.97	47-48	9.89	15.63
08-09	18.31	27.50	48-49	11.48	14.72
1909-10	14.56	18.47	1949-50	8.31	16.71
10-11	22.65	22.54	50-51	14.01	27.04
11-12	10.59	13.62	51-52	19.75	31.81
12-13	6.35	10.14	52-53	9.62	19.97
Mean for 50-year period, 1897-98 through 1946-47			13.72		19.92
Average for period of record			14.16		20.41
Average for 13-year base period, 1935-36 through 1947-48			13.86		-----
Average for 16-year base period, 1932-33 through 1947-48			-----		20.76

Mean seasonal depth of precipitation from north to south ranges from 15.93 inches at Palo Alto to 13.72 inches at San Jose, to 19.90 inches at Morgan Hill, and 19.92 inches at Gilroy. Similarly, from west to east, it ranges from 43.57 inches at Los Gatos Summit, to 28.94 inches at Los Gatos, and 27.31 inches at Lick Observatory on Mount Hamilton. In the Santa Cruz Mountains, the mean seasonal depth of precipitation exceeds 50 inches in some small areas, but decreases in an easterly direction with distance from the mountain crest to a minimum near the center of the valley. In the eastern portions of the Santa Clara Valley, and in the Diablo Range, increasing elevations bring greater seasonal precipitation. However, it does not reach the high mean values found in the Santa Cruz Mountains.

Precipitation in the Santa Clara Valley varies over wide limits from season to season, having ranged from less than 40 per cent of the seasonal mean to more than 200 per cent. The maximum seasonal depth of precipitation at San Jose and Gilroy occurred in 1889-90 when 30.30 inches and 48.04 inches of rainfall were recorded, respectively. In 1876-77, the minimum season at these stations, the depth of precipitation was only 4.83 inches and 7.66 inches, respectively. Long-term trends in precipitation for the Santa Clara Valley are indicated on Plate 4, entitled "Accumulated Departure From Mean Seasonal Precipitation at San Jose and Gilroy."

More than 80 per cent of the seasonal precipitation in the Santa Clara Valley occurs during the five months from November through March. The remaining months of the year are correspondingly dry, and only traces of rainfall occur in July and August. Mean monthly distribution of precipitation as recorded at San Jose and Gilroy is presented in Table 3.

TABLE 3
MEAN MONTHLY DISTRIBUTION OF PRECIPITATION
AT SAN JOSE AND GILROY

Month	San Jose		Gilroy	
	In inches of depth	In percent of seasonal total	In inches of depth	In percent of seasonal total
July	0.00	0.0	0.01	0.0
August	0.02	0.2	0.01	0.0
September	0.30	2.2	0.22	1.1
October	0.65	4.7	0.74	3.7
November	1.21	8.8	1.89	9.5
December	2.30	16.8	3.60	18.1
January	2.84	20.7	4.36	21.9
February	2.65	19.3	3.89	19.5
March	2.27	16.6	3.36	16.9
April	0.91	6.6	1.21	6.1
May	0.47	3.4	0.53	2.7
June	0.10	0.7	0.10	0.5
TOTALS	13.72	100.0	19.92	100.0

TABLE 4
ESTIMATED WEIGHTED SEASONAL DEPTH AND TOTAL QUANTITY OF
PRECIPITATION ON SANTA CLARA VALLEY

Season	North Santa Clara Valley					South Santa Clara Valley				
	Precipitation index	Forebay Zone		Pressure Zone		Precipitation index	Forebay Zone		Pressure Zone	
		Depth, in inches	Quantity, in acre-feet	Depth, in inches	Quantity, in acre-feet		Depth, in inches	Quantity, in acre-feet	Depth, in inches	Quantity, in acre-feet
Average for 13-year base period, 1935-36 through 1947-48	101	20.2	145,600	15.2	99,600					
Average for 16-year base period, 1932-33 through 1947-48						104	22.8	60,400	19.8	33,700
Mean for 50-year period, 1897-98 through 1946-47	100	20.0	144,200	15.1	99,000	100	21.9	58,000	19.0	32,300

Quantity of Precipitation

The mean seasonal quantity of precipitation in the Santa Clara Valley was estimated by plotting recorded or estimated mean seasonal depth of precipitation at stations in or near the area on a map. Lines of equal mean seasonal precipitation, or isohyets, were then drawn, as are shown on Plate 2. By planimetry the areas between these isohyets, the weighted mean seasonal depth and total quantity of precipitation were estimated for North and South Santa Clara Valleys, and for the segregation of these two subareas into forebay and pressure zones, which segregation is discussed in the ensuing section on "Underground Hydrology."

In order to determine seasonal depth and quantity of precipitation during the respective base periods, the foregoing estimates for the mean period were adjusted on the basis of recorded precipitation at San Jose and Gilroy. The results of the estimates are presented in Table 4, which also shows the precipitation index for the base periods. The term "precipitation index" refers to the ratio of the amount of precipitation during a given season to the mean seasonal amount, and is expressed as a percentage.

RUNOFF

Runoff from the tributary watersheds of the Santa Clara Valley constitutes the major source of water available to replenish the ground water basin. The two most important streams contributing surface inflow to North Santa Clara Valley are Coyote and Los Gatos Creeks. Runoff in these streams comprises about 30 and 18 per cent, respectively, of the tributary surface inflow, while the many smaller streams discharge the remaining 52 per cent. A large part of the surface inflow tributary to South Santa Clara Valley is contributed by Uvas and Llagas Creeks, which supply 41 per cent and 27 per cent, respectively, of the total surface inflow to that valley.

Stream Gaging Stations and Records

Available records of runoff of principal streams in the Santa Clara Valley were sufficient in number, length, and reliability for purposes of required hydrographic studies. With respect to certain of the smaller streams, however, records of runoff were nonexistent or confined principally to measurements made during the investigational season of 1948-49. By comparison with records of nearby stations on major streams, adequate estimates were made of runoff of these smaller streams.

Table 5 lists those stream gaging stations pertinent to the hydrography of the investigational area, together with their map reference numbers, drainage areas above stations where significant, and periods and sources of records. These stations are also shown on Plate 2. The map reference numbers for the first seven stations listed under "Northern Inflow," the first two listed under "Northern Outflow," and that for Uvas Creek near Morgan Hill, correspond to those used in State Water Resources Board Bulletin No. 1, "Water Resources of California." New map reference numbers were assigned to the remaining stations listed and are designated by the prefix "SC." The last four stations listed in Table 5 were installed, operated, and maintained as a part of the Santa Clara Valley Investigation.

Runoff records of stations maintained by the United States Geological Survey have been published in its Water-Supply Papers. The records of stations maintained by the Santa Clara Valley Water Conservation District, the South Santa Clara Valley Water Conservation District, and the Division of Water Resources not previously published are included in Appendix E.

Runoff Characteristics

An excellent continuous record of the flow of Coyote Creek near Madrone is available for the period since December, 1916, when a stream gaging station was established by the United States Geological Survey. This record provides a measure of flow of Coyote

TABLE 5
STREAM GAGING STATIONS IN SANTA CLARA VALLEY

Map reference number	Stream	Station	Drainage area, in square miles	Period of record	Source of record
Northern Inflow					
2-39	Coyote Creek (River)	near Madrone	193.0	1902-1912, 1916-1953	USGS
2-45	Alamitos Creek	near Edenvale	35.0	1930-1953	USGS, DWR
2-46	Los Capitancillos (Guadalupe) Creek	at Guadalupe	12.6	1930-1943, 1945-1953	USGS, DWR
2-48	Los Gatos Creek	at Los Gatos	40.0	1930-1944	USGS, DWR
2-49	Los Gatos Creek	below Los Gatos	43.6	1944-1953	USGS
2-50	Campbell Creek	at Saratoga	8.8	1938-1953	USGS
2-9	Stevens Creek	near Cupertino	18.1	1930-1953	USGS, DWR
SC-1	Penitencia Creek	near Noble Avenue	23.4	1934-1946	SCVWCD
SC-1A	Penitencia Creek	at Mitchell's Dam	---	1946-1953	SCVWCD
SC-4	Dry Creek	Penitencia percolation ponds	---	1934-1953	SCVWCD
SC-5	Silver Creek	near Yerba Buena Road	9.5	1932-1944	SCVWCD
SC-6	Fisher Creek	at Silver Creek Road	5.3	1934-1944	SCVWCD
SC-7	San Tomas Aquinas Creek	at U. S. Highway 101	9.4	1934-1953	SCVWCD
SC-7A	San Tomas Aquinas Creek	at McCoy Road	6.2	1942-1945	SCVWCD
SC-7B	Wildcat Creek	at Pollard Road	4.3	1932-1942, 1945-1951	SCVWCD, DWR
SC-7C	Smith's Creek	at Southern Pacific Railroad	---	1939-1942, 1945-1951	SCVWCD
SC-10	Calabazas Creek	at Quito Road	3.7	1938-1945, 1945-1951	SCVWCD
SC-13	Permanente Creek	at San Tomas Road	2.3	1932-1945	SCVWCD, DWR
SC-13A	Magdalena Creek	Smiths Dam near Elam Road	4.1	1945-1951	SCVWCD, DWR
2-11	San Francisquito Creek	at Sunnyvale-Saratoga Road	8.0	1932-1945	SCVWCD, DWR
		at Southern Pacific Railroad near Azule Station	---	1945-1951	SCVWCD, DWR
		near Loyola	2.8	1932-1945	SCVWCD
		at Holly Ranch	---	1945-1951	SCVWCD
		at Fremont Road	---	1938-1946	USGS, DWR
		near Magdalena Road	---	1946-1951	USGS, DWR
		at Stanford University	37.7	1931-1941, 1949-1953	USGS, DWR
Northern Outflow					
2-43	Coyote Creek	near Edenvale	229.0	1916-1953	USGS
2-47	Guadalupe River (Creek)	at San Jose	131.0	1930-1953	USGS, DWR
SC-2	Penitencia Creek	near King Road	25.7	1932-1953	SCVWCD, DWR
SC-3	Silver-Dry Creek	at Capitol Avenue	33.8	1932-1948	SCVWCD, DWR
SC-8	San Tomas Aquinas Creek	at U. S. Highway 101	17.4	1932-1945	SCVWCD, DWR
SC-9	Campbell Creek (Saratoga Creek)	at Homestead Road	---	1945-1953	SCVWCD, DWR
SC-11	Calabazas Creek	at U. S. Highway 101	16.2	1932-1949	SCVWCD, DWR
SC-12	Stevens Creek	at Stevens Creek Road	11.9	1949-1953	SCVWCD, DWR
SC-14	Permanente Creek	at U. S. Highway 101	7.8	1932-1945	SCVWCD, DWR
2-15	San Francisquito Creek	at Pomeroy Avenue	---	1945-1953	SCVWCD, DWR
		at Southern Pacific Railroad, Mountain View	23.7	1932-1953	SCVWCD, DWR
		Southern Pacific Railroad	---	1938-1942	SCVWCD
		at California Street, Mountain View	12.7	1942-1953	USGS
		at Palo Alto	38.6	1931-1940	USGS
Southern Inflow					
SC-15	Llagas Creek	near Lane Avenue Bridge	19.6	1942-1953	SSCVWCD, DWR, USGS
3-9	Uvas Creek	near Morgan Hill	30.2	1930-1953	USGS
SC-16	Little Arthur Creek	near Adams School	9.6	1948-1949	DWR
SC-17	Bodfish Creek	near Gilroy	12.4	1948-1949	DWR
Southern Outflow					
SC-18	Llagas Creek	at Pacheco Pass Road	66.5	1948-1949	DWR
SC-19	Carnadero Creek	at Bloomfield Avenue	85.2	1948-1949	DWR

USGS—United States Geological Survey.
DWR—State Division of Water Resources.
SCVWCD—Santa Clara Valley Water Conservation District.
SSCVWCD—South Santa Clara Valley Water Conservation District.

Creek into North Santa Clara Valley. A good record of flow of this stream at about the same location exists for the period from October, 1902, to September, 1912. Since Coyote Creek is by far the largest tributary stream, and because of its length of record, it was considered that its record of flow more nearly reflects characteristics of tributary runoff to North Santa Clara Valley than do records of flow of other tributary streams.

The flow of Coyote Creek near Madrone is impaired by operation of Coyote and Anderson Reservoirs, lo-

cated upstream from this station. An estimate of the natural runoff of Coyote Creek near Madrone, as it would be if unaltered by upstream diversion, storage, importation, or exportation, is included in State Water Resources Board Bulletin No. 1, "Water Resources of California." This estimate, as revised and extended, is presented in Table 6. The estimate of natural flow is also shown graphically on Plate 5, entitled "Recorded and Estimated Seasonal Natural Runoff of Coyote Creek Near Madrone and Uvas Creek Near Morgan Hill."

An excellent continuous record of flow of Uvas Creek near Morgan Hill is available for the period since December, 1930, when a stream gaging station was established at the present location by the United States Geological Survey. This record provides a measure of the natural flow of Uvas Creek into South Santa Clara Valley, since impairment of flow upstream from the station is small. This estimate is presented in Table 6 and shown graphically on Plate 5.

Estimates of natural flow of streams tributary to the Santa Clara Valley indicate that average seasonal runoff during the 13-year base period for North Santa Clara Valley, and the 16-year base period for South Santa Clara Valley, approximated the seasonal mean during the 53-year period. These estimates, obtained from State Water Resources Board Bulletin No. 1 and revised and extended, are presented in Table 7, together with runoff indices for the combined natural flow. The term "runoff index" refers to the ratio of

TABLE 6
RECORDED AND ESTIMATED SEASONAL NATURAL RUN-OFF OF COYOTE CREEK NEAR MADRONE AND UVAS CREEK NEAR MORGAN HILL

(In acre-feet)

Season	Coyote Creek near Madrone	Uvas Creek near Morgan Hill	Season	Coyote Creek near Madrone	Uvas Creek near Morgan Hill
1894-95	161,300*	57,300*	1929-30	20,100	6,800*
95-96	67,200*	48,500*	30-31	1,670	1,400*
96-97	123,500*	34,600*	31-32	69,800	32,700
97-98	1,700*	2,400*	32-33	8,110	5,600
98-99	31,300*	11,700*	33-34	10,700	10,100
1899-1900	23,200*	19,100*	1934-35	32,000	15,500
00-01	67,200*	50,000*	35-36	54,300	25,300
01-02	44,400*	19,100*	36-37	72,200	31,400
02-03	83,200	21,100*	37-38	155,700	68,000
03-04	35,800	27,900	38-39	10,800	4,600
1904-05	31,800	21,000	1939-40	76,700	44,500
05-06	117,000	42,200	40-41	146,900	57,500
06-07	204,000	42,900	41-42	76,900	38,800
07-08	47,200	13,400*	42-43	68,700	27,800
08-09	176,000	51,500*	43-44	50,000	17,300
1909-10	51,100	16,100*	1944-45	53,700	25,000
10-11	126,000	57,900*	45-46	29,600	15,200
11-12	6,380	4,900*	46-47	9,000	10,000
12-13	3,850*	1,500*	47-48	4,800	6,000
13-14	189,000*	54,500*	48-49	19,100	13,800
1914-15	121,000*	46,400*	1949-50	14,000	10,800
15-16	153,000*	54,300*	50-51	60,400	39,200
16-17	70,200	40,200*	51-52	113,700	54,900
17-18	13,400	13,700*			
18-19	47,500	11,800*	53-year mean, 1894-95 through 1946-47	61,700	26,500
1919-20	14,000	8,000*			
20-21	56,800	15,900*	13-year average, 1935-36 through 1947-48	62,300	
21-22	69,100	48,300*			
22-23	50,700	26,900*	16-year average, 1932-33 through 1947-48		25,200
23-24	880	1,900*			
1924-25	13,200	8,100*			
25-26	40,300	35,100*			
26-27	53,300	40,200*			
27-28	22,500	13,500*			
28-29	7,250	7,700*			

* Estimated.

the amount of runoff during a given season to the mean seasonal amount, and is expressed as a percentage.

Discharge of streams tributary to the Santa Clara Valley vary between wide limits from season to season, and within the season. This is indicated by the flow of Coyote Creek near Madrone and Uvas Creek near Morgan Hill. The maximum recorded seasonal runoff of Coyote Creek occurred in 1906-07 and amounted to 204,000 acre-feet, while the maximum for Uvas Creek occurred in 1937-38 and amounted to 68,000 acre-feet. The minimum seasonal runoffs recorded at both stations occurred in 1930-31, and amounted to 1,670 acre-feet and 1,400 acre-feet, respectively. Maximum recorded instantaneous discharge on Coyote Creek was about 25,000 second-feet, which probably occurred on March 7, 1911, and maximum recorded instantaneous discharge on Uvas Creek was about 8,600 second-feet on December 11, 1937. Both creeks have been dry at times. Estimated mean monthly distribution of natural flow of Coyote Creek near Madrone and Uvas Creek near Morgan Hill is presented in Table 8. Long-term trends in runoff of these streams are indicated on Plate 6, entitled "Accumulated Departure From Mean Seasonal Natural Runoff of Coyote Creek Near Madrone and Uvas Creek Near Morgan Hill."

Quantity of Runoff

Available records of stream flow, including those obtained from measurements made in connection with the investigation, were sufficient to permit reliable determination of surface inflow to and outflow from the area of investigation during the respective base periods for North Santa Clara Valley and South Santa Clara Valley.

Inflow to the Forebay Zone of North Santa Clara Valley was measured at the stations listed under "Northern Inflow" in Table 5. Inflow to the Forebay Zone of South Santa Clara Valley was measured at the stations listed under "Southern Inflow." The estimated inflow from unmeasured watersheds was derived from estimated unit values of runoff per square mile multiplied by the areas of the watersheds. The unit values of runoff were determined by comparison with that from nearby measured watersheds with similar watershed and runoff characteristics. Records of runoff of short duration were extended to cover each season of the 53-year mean period by correlation with flow at nearby stations having a long record.

Surface outflow from the Forebay Zone of North Santa Clara Valley was measured at the stations listed under "Northern Outflow" in Table 5. Unmeasured surface outflow during the 13-year base period was estimated from correlation with recorded outflow in a manner similar to that used in estimating surface inflow. In South Santa Clara Valley, the base period surface outflow from the Forebay Zone was estimated

SANTA CLARA VALLEY INVESTIGATION

TABLE 7
ESTIMATED SEASONAL NATURAL FLOW OF STREAMS TRIBUTARY TO SANTA CLARA VALLEY
(In acre-feet)

Season	North Santa Clara Valley										South Santa Clara Valley			
	Runoff index	Coyote Creek near Madrone	Minor east-side streams	Los Capitancillos Creek at Guadalupe	Alamitos Creek near Edenvale	Los Gatos Creek at Los Gatos	Stevens Creek near Cupertino	Minor west-side streams	San Francisco Creek at Stanford	Combined flow	Runoff index	Llagas Creek near Morgan Hill	Uvas Creek near Morgan Hill	Combined flow
1932-33.....											19	2,300	5,600	7,900
33-34.....											46	9,200	10,100	19,300
1934-35.....											63	11,000	15,500	26,500
35-36.....	82	54,500	24,100	6,500	9,800	28,600	6,900	21,400	12,800	164,600	97	15,300	23,300	40,600
36-37.....	114	72,200	30,300	9,800	17,700	37,000	9,400	32,900	20,300	229,600	117	17,800	31,400	49,200
37-38.....	250	155,700	64,100	22,600	48,100	82,200	23,100	72,100	34,300	502,200	254	38,600	68,000	106,600
38-39.....	16	10,800	4,700	2,000	700	6,200	2,100	3,800	1,500	31,800	20	3,800	4,600	8,400
1939-40.....	146	76,700	30,800	12,700	23,900	59,700	18,500	46,900	25,300	294,500	159	22,100	44,500	66,600
40-41.....	247	146,900	64,800	17,200	38,700	81,400	28,300	89,100	31,500	497,900	246	45,500	57,500	103,000
41-42.....	144	76,900	33,600	13,100	24,500	53,900	17,800	46,100	24,100	290,000	147	23,000	38,800	61,800
42-43.....	107	68,700	26,000	8,300	17,900	36,300	11,900	28,500	17,100	214,700	99	13,500	27,800	41,300
43-44.....	62	50,000	20,400	5,400	7,200	19,000	4,200	14,300	4,800	125,300	60	8,000	17,300	25,300
1944-45.....	84	53,700	21,800	7,300	11,900	32,900	7,500	21,100	11,900	168,100	81	9,100	25,000	34,100
45-46.....	56	29,600	11,400	5,300	7,400	26,100	7,900	16,900	8,200	112,800	60	10,000	15,200	25,200
46-47.....	17	9,000	2,500	2,100	1,400	9,300	3,600	5,100	1,400	34,400	38	6,000	10,000	16,000
47-48.....	16	4,800	1,700	3,100	2,300	12,300	2,000	4,200	2,500	32,900	21	2,900	6,000	8,900
Average for 13-year base period.....	103	62,300	25,900	8,900	16,300	37,300	11,000	30,900	15,100	207,700				
Average for 16-year base period.....											96	14,900	25,200	40,100
53-year mean.....	100	61,700	25,600	8,700	16,100	35,800	9,800	29,200	14,300	201,200	100	15,400	26,500	41,900

TABLE 8
ESTIMATED MEAN MONTHLY DISTRIBUTION OF NATURAL FLOW OF COYOTE CREEK NEAR MADRONE AND UVAS CREEK NEAR MORGAN HILL

Month	Coyote Creek		Uvas Creek	
	Runoff, in acre-feet	Percent of seasonal total	Runoff, in acre-feet	Percent of seasonal total
October.....	200	0.3	40	0.2
November.....	500	0.8	300	1.1
December.....	3,700	6.0	2,500	9.4
January.....	9,300	15.1	4,200	15.9
February.....	21,000	34.0	9,000	34.0
March.....	15,700	25.5	5,900	22.2
April.....	7,400	12.0	3,300	12.4
May.....	2,500	4.1	800	3.0
June.....	600	1.0	300	1.1
July.....	400	0.6	100	0.4
August.....	200	0.3	40	0.2
September.....	200	0.3	20	0.1
TOTALS.....	61,700	100.0	26,500	100.0

from seasonal inflow to the valley floor, and from stream percolation measurements made in 1948-49 at the stations listed in Table 5 under "Southern Outflow."

Measured and estimated seasonal surface inflow to and outflow from the Forebay Zones of North and South Santa Clara Valleys during the mean and base periods are presented in Table 9.

Imported and Exported Water

Water is imported to North Santa Clara Valley for municipal use in the Cities of Palo Alto, Sunnyvale, and Milpitas, and for use at Moffett Field by the United States Navy. The imported water supplies are purchased from the City of San Francisco. A portion of the imported water originates on the west slope of the Sierra Nevada in the Tuolumne River watershed, and the remainder on the Diablo Range in the Alameda Creek watershed. No water is imported to South Santa Clara Valley.

Seasonal importations to North Santa Clara Valley averaged about 2,000 acre-feet during the 13-year base period from 1935-36 through 1947-48. Present average seasonal importation, assumed to be somewhat greater than the 1947-48 value, is about 4,000 acre-feet. Table 10 indicates the amounts of importation of water to North Santa Clara Valley for each season of the 13-year period. So far as was determined during the investigation, there were no exports of water from Santa Clara Valley.

UNDERGROUND HYDROLOGY

Water pumped from the ground water basins of the Santa Clara Valley meets nearly all of the irrigation, domestic, and industrial demands of individuals and organizations in the valley. Percolation of rainfall, stream flow, drainage from adjacent hills, sub-

TABLE 9
ESTIMATED SEASONAL SURFACE INFLOW TO AND OUTFLOW FROM
FOREBAY ZONES OF SANTA CLARA VALLEY

(In acre-feet)

Subarea and stream	Surface inflow			Surface outflow		
	53-year mean, 1894-95 through 1946-47	13-year average, 1935-36 through 1947-48	16-year average, 1932-33 through 1947-48	53-year mean, 1894-95 through 1946-47	13-year average, 1935-36 through 1947-48	16-year average, 1932-33 through 1947-48
North Santa Clara Valley						
San Francisquito Creek	14,300	15,100	-----	12,200	12,300	-----
Permanente Creek	3,100	3,200	-----	2,400	2,300	-----
Stevens Creek	9,800	10,800	-----	3,700	3,700	-----
Calabazas Creek	2,200	1,500	-----	1,100	1,100	-----
Campbell Creek	6,500	7,500	-----	4,000	4,000	-----
San Tomas Aquinas Creek	3,600	4,100	-----	1,900	1,900	-----
Los Gatos Creek	35,800	37,300	-----	-----	-----	-----
Los Alamos Creek	^a 18,100	^a 17,700	-----	-----	-----	-----
Guadalupe Creek	8,700	8,800	-----	-----	-----	-----
Guadalupe River ^b	-----	-----	-----	32,300	32,600	-----
Fisher Creek	4,600	4,700	-----	-----	-----	-----
Coyote Creek	61,700	60,900	-----	^c 41,100	^c 41,400	-----
Silver and Dry Creeks	3,600	3,900	-----	700	700	-----
Penitencia Creek	6,000	5,900	-----	2,400	2,500	-----
Unmeasured	25,200	26,100	-----	8,200	8,800	-----
TOTALS	203,000	207,500	-----	110,000	111,300	-----
South Santa Clara Valley						
Llagas Creek	15,400	-----	14,900	9,500	-----	9,300
Uvas Creek	26,500	-----	25,200	31,200	-----	30,500
Unmeasured	18,700	-----	17,000	9,300	-----	9,200
TOTALS	60,600	-----	57,100	50,000	-----	49,000

^a Includes an estimated 2,000 acre-feet that percolates above the gaging station.^b Includes outflow from Los Gatos, Guadalupe, and Los Alamos Creeks.^c Includes outflow from Fisher Creek.

TABLE 10
SEASONAL IMPORTATION OF WATER
TO NORTH SANTA CLARA VALLEY,
1935-36 THROUGH 1947-48
(In acre-feet)

Season	Importation
1935-36	0
36-37	0
37-38	0
38-39	860
1939-40	1,990
40-41	2,140
41-42	2,080
42-43	2,450
43-44	2,470
1944-45	2,650
45-46	2,760
46-47	3,050
47-48	3,600
AVERAGE	1,850

surface inflow, and the unconsumed portion of applied irrigation water, are the most important sources of ground water replenishment.

The term "free ground water," as used in this bulletin, generally refers to a body of ground water not overlain by impervious materials and moving under control of the water table slope. "Confined

ground water" refers to a body of ground water overlain by material sufficiently impervious to sever free hydraulic connection with overlying water, and moving under pressure caused by the difference in head between intake and discharge areas of the confined water body. In areas of free ground water, the ground water basin provides regulatory storage to smooth out fluctuations in available water supplies, and changes in ground water storage are indicated by changes in ground water levels.

Data and information collected during the Santa Clara Valley Investigation indicate that both free ground water and confined ground water bodies exist in present zones of pumping. Study of historic fluctuations of water levels in the Santa Clara Valley, under varying conditions of draft and replenishment, permitted a determination of changes in ground water storage in the basins, and their safe yield of water under stated conditions.

Ground Water Geology

Geologic features of the ground water basin underlying the Santa Clara Valley were investigated by the Division of Water Resources in connection with the current investigation. Appendix C comprises a somewhat detailed report covering geologic features of the Santa Clara Valley. Included with the report

are a general geologic map, columnar sections, and geologic sections.

The water-bearing sediments of the Santa Clara Valley occupy the valley proper and some adjacent areas. At depth these sediments are underlain by older nonwater-bearing rocks, which also flank the water-bearing materials around the margin of the valley.

The age of the water-bearing sediments is Plio-Pleistocene and upper Quaternary. The Plio-Pleistocene sediments consist of up to 4,000 feet of continental sand, gravel, and clay, and locally include some carbonate, lignite, and basalt. These deposits have been faulted and folded by the middle Pleistocene disturbance which affected the entire California Coast Ranges. The Plio-Pleistocene sediments supply water to deep wells in areas where the upper Quaternary sediments are thin, and to small domestic wells in the hills surrounding the valley.

Upper Quaternary sediments are the main source of ground water in the Santa Clara Valley. These sediments consist of flood plain deposits, alluvial fan deposits, and tideland or marine swamp deposits, of which the alluvial fan and tideland deposits form the largest part. The sediments include up to 1,000 feet of poorly sorted gravel, sand, and clay. Various mixtures of these sedimentary types are common, and the coarser sediments in particular generally occur as lenses and stringers, rather than as widespread layers of homogeneous material.

Gravels are the main aquifers in the upper Quaternary sediments. Water-yielding sands are also present, but wells in this area are not generally perforated in sand strata. The tideland deposits consist of fairly continuous blue clays, which cap the pressure area of North Santa Clara Valley. The blue clays have their greatest thickness in the area around the southernmost portion of San Francisco Bay, and thin out toward Milpitas, San Jose, Sunnyvale, and Palo Alto. The blue clays dip gently toward San Francisco Bay, the dip probably being in part the original attitude of the sediments and in part due to greater compaction of the sediments in the central part of the valley.

The blue clays in South Santa Clara Valley dip gently southward, and increase in thickness from San Martin toward the Pajaro River. These blue clays were originally deposited in fresh-water lakes and swamps, and now form the capping beds of a pressure area.

No definite evidence was found during this investigation that faulting has disturbed the upper Quaternary sediments in the Santa Clara Valley, although fault barriers in alluvium do exist in Alameda County to the north and San Benito County to the south. If faulted upper Quaternary sediments do exist in Santa Clara County, the faults apparently do not form barriers to ground water movement.

Ground Water Basins

During the current and previous investigations, two major ground water basins in the Santa Clara Valley have been identified. These ground water basins are separated by a low divide near Morgan Hill and underlie North and South Santa Clara Valleys, respectively.

The geologic and hydrologic studies made of the valley fill in the Santa Clara Valley indicated that, over portions of the valley, relatively impervious and generally continuous strata exist between the ground surface and the principal pumping aquifers. Such strata appear to prevent significant quantities of rainfall, stream flow, or unconsumed water applied to irrigation from percolating to the deeper water-bearing strata. Consequently, the principal pumping aquifers, overlain by the relatively impervious strata, contain confined water exhibiting pressure characteristics. Conversely, free ground water or forebay zones, found generally upstream from the pressure zones, contain unconfined ground water, and are replenished by percolating rainfall, percolating irrigation water, percolating surface stream flow, percolation from ponds, and sub-surface inflow. In addition to supplying water for use on overlying lands, these unconfined ground water bodies act as forebays, supplying the pressure zones by underflow.

The pressure zone in North Santa Clara Valley covers an area extending from about four miles southeast of the City of San Jose to San Francisco Bay on the north, and from near Palo Alto on the west to near Milpitas on the east. The pressure zone in South Santa Clara Valley covers an area extending from about two miles southeast of San Martin to the Pajaro River on the south, and along the Pajaro River from near Sargent on the west to near San Felipe Lake on the east. The forebay zone in North Santa Clara Valley lies upstream and adjacent to the pressure zone, and generally extends to the valley floor-foothill line on the west and east, and to the south boundary of North Santa Clara Valley near Morgan Hill. The forebay zone in South Santa Clara Valley lies between the boundary of the pressure zone in that valley and the valley floor-foothill line on the west and east, and extends northwest to the north boundary of South Santa Clara Valley near Morgan Hill. The forebay zones in North and South Santa Clara Valleys comprise about 86,500 and 26,600 acres, respectively. The pressure zones comprise about 78,600 and 20,400 acres, respectively. The locations of zones of free and confined ground waters are shown on Plate 7, entitled "Lines of Equal Depth to Ground Water, Fall of 1953." Plate 8, entitled "Diagrammatic Profiles of Pressure and Forebay Zones in North and South Santa Clara Valleys," shows the relative positions of the forebay and pressure zones, as well as the relative positions of water table and piezometric surfaces at the time of the investigation.

Methods of confirming the presence of and delimiting the boundaries between forebay and pressure zones in the two major divisions of the Santa Clara Valley were primarily geologic and hydrologic. In connection with the geologic studies, 1,100 well logs were obtained from local well drillers and other sources, and the well locations were indicated on maps. Logs indicating the presence of blue clay were noted, and lines drawn on a map showing upstream limits of the blue clay capping strata provided one criterion for locating pressure zone boundaries.

A hydrologic method utilized for differentiating between pressure and free ground water bodies was based upon the characteristics exhibited by these bodies under conditions of change in rate of pumping draft. Over a period of several days, water stage recorders were installed on abandoned wells to differentiate the high amplitude and cyclic piezometric surface fluctuation of ground water under pressure from the gradual water table elevation changes in free ground water zones. Another method utilized consisted of the preparation of a ground water map showing lines of equal change in ground water elevation for the period from summer to fall in 1949, which map differentiated characteristic positive changes in levels of confined ground water from characteristic negative changes in the free ground water zones.

In addition to the foregoing criteria for determining pressure zone boundaries, the limits of the area within which artesian wells were once found in North and South Santa Clara Valleys, as reported in United States Geological Survey Water-Supply Paper No. 519, were noted. Artesian flow of water from wells is indicative of ground water under pressure.

For North Santa Clara Valley only, the area over which land surface subsidence occurred between 1933 and 1948 was considered. The area of subsidence is related to the zone of confined ground water, since it is believed that ground surface lowering has resulted from compaction of the capping clay strata under reduced hydrostatic pressures.

The foregoing considerations resulted in several lines of demarcation between pressure and forebay zones in North and South Santa Clara Valleys, which agreed within reasonable limits.

Evidence indicates that the pressure zones of both North and South Santa Clara Valleys extend beyond the limits defined in this investigation. The zone of confinement in North Santa Clara Valley extends northward both under San Francisco Bay and under lands east and west and adjacent to this body of water. The pressure zone in South Santa Clara Valley continues southward beyond the Pajaro River into San Benito County.

Aquifers beneath the aforementioned capping clay beds are the principal sources of ground water utilized in these pressure zones. Perched ground waters exist in both North and South Santa Clara Valleys

above these beds, but are not used extensively because of their poor quality or insufficiency of yield of wells.

Specific Yield and Ground Water Storage Capacity

The term "specific yield," when used in connection with ground water, refers to the ratio of the volume of water a saturated soil will yield by gravity to its own volume, and is commonly expressed as a percentage. Ground water storage is estimated as the product of the specific yield and the volume of material in the depth intervals considered.

As has been stated, during the investigation some 1,100 well logs were collected, identified, and located on a map. Sources of the well logs included private owners, well drillers, public agencies, and private organizations. Average values of specific yield for the forebay zones in North and South Santa Clara Valleys were computed for each 25-foot depth interval from the ground surface to 300 feet below the surface, in the manner described in Division of Water Resources Bulletin No. 45.

The weighted average specific yield of sediments of the valley fill for the depth interval from 25 to 300 feet below the ground surface in the North Santa Clara Valley forebay zone was estimated to be 7.4 per cent. In the forebay zone of South Santa Clara Valley, the average specific yield of the alluvium in the depth interval from 25 to 300 feet below the ground surface was estimated to be about 6.5 per cent.

Ground water storage capacity was estimated as the product of the weighted specific yield of the zones, and the volume of material in the depth intervals considered. For the zone from 0 to 300 feet below the surface in North and South Santa Clara Valleys, the total ground water storage capacities were estimated to be approximately 1,900,000 acre-feet and 510,000 acre-feet, respectively. Of this total capacity, only that between the limits of 25 and 200 feet below the ground surface was considered to be usable. Total usable storage volumes in these depth zones for North and South Santa Clara Valleys were estimated to be about 1,250,000 and 300,000 acre-feet, respectively.

Table 11 presents estimated weighted average specific yields and ground water storage capacities for 25-foot depth intervals in North and South Santa Clara Valleys.

Ground Water Levels

Records of ground water level measurements are available for an extended period for both North and South Santa Clara Valleys. The Santa Clara Valley Water Conservation District, encompassing most of the northern valley, has measured depth to ground water at about 250 wells each year since 1933. Earlier records of well measurements in

TABLE 11

ESTIMATED SPECIFIC YIELD AND GROUND WATER STORAGE CAPACITY, SANTA CLARA VALLEY

Depth interval, in feet below ground surface	North Santa Clara Valley		South Santa Clara Valley	
	Weighted average specific yield, in per cent	Ground water storage capacity, in acre-feet	Weighted average specific yield, in per cent	Ground water storage capacity, in acre-feet
0-25-----	6.2	134,000	5.7	38,000
25-50-----	8.7	188,000	6.1	41,000
50-75-----	8.4	183,000	7.1	47,000
75-100-----	8.7	188,000	5.9	39,000
100-125-----	8.3	179,000	7.6	51,000
125-150-----	7.8	168,000	6.8	45,000
150-175-----	8.1	176,000	6.7	45,000
175-200-----	7.9	171,000	5.4	36,000
200-225-----	7.0	152,000	6.7	45,000
225-250-----	6.0	131,000	7.4	49,000
250-275-----	5.7	123,000	6.8	45,000
275-300-----	5.2	112,000	4.7	32,000
TOTALS-----		1,905,000		513,000

North Santa Clara Valley may be found in a report to the Santa Clara Valley Water Conservation District Committee by Tibbetts and Kieffer, dated March, 1921, in Division of Water Resources Bulletin No. 42, and in United States Geological Survey Water-Supply Papers 400 and 519.

In connection with the current investigation, the Division of Water Resources measured depth to ground water at about 500 wells in North Santa Clara Valley in the spring and fall seasons of 1948, 1949, and 1950, and made monthly well measurements at 35 key wells during 1948 and 1949. In South Santa Clara Valley measurements of depth to ground water were made at about 290 wells in the spring and fall seasons of 1948, 1949, and 1950, and monthly measurements were made at 65 key wells in 1948 and 1949. The wells were chosen to form a comprehensive grid covering the entire area. Measurements made by the Division of Water Resources during the current investigation, and records of depth to ground water at selected wells in the Santa Clara Valley for years prior to the investigation, are included as Appendix F to this bulletin.

Depths to ground water in the Santa Clara Valley as measured each fall from 1948 through 1953 were plotted on maps and lines of equal depth to ground water were drawn. An example of these maps is shown on Plate 7. Plate 9, entitled "Lines of Equal Elevation of Ground Water, Fall of 1953," was prepared from the data used for Plate 7, depths to ground water being subtracted from elevations of the measuring points above sea-level to obtain elevations of the ground water level.

Table 12 shows depths from the ground surface to water levels at selected representative wells in the Santa Clara Valley during the fall of most years

from 1914 to 1953. Fluctuations in depth to ground water at certain of these wells are depicted graphically on Plate 10, entitled "Measured Depths to Water Level at Selected Wells."

The wells are numbered by the system utilized by the United States Geological Survey, according to township, range, and section. Under this system each section is divided into 40-acre plots which are lettered as follows:

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

Wells are numbered within each of these 40-acre plots according to the order in which they are located. For example, a well having a number 7S/1W-13H2 would be found in Township 7 South, Range 1 West, and in Section 13. It would be further identified as the second well located in the 40-acre plot lettered H.

From study of all available well measurements, estimates were made of the approximate average depth to ground water in the forebay zones of the Santa Clara Valley in the fall of each year from 1932 through 1953. These values, which constitute arithmetical averages of available measurements, and weighted averages for years for which maps showing ground water depths were drawn, are presented in Table 13, and are illustrated graphically on Plate 11, entitled "Average Fall Depth to Ground Water in Forebay Zones."

It is indicated in Table 13 that a moderate rise of ground water levels in North Santa Clara Valley occurred from 1935 to 1938, followed by a lowering in 1939, and a rise again to a maximum in 1942. In that year the estimated average depth to ground water was the least during the period from 1932 through 1953. Following 1942, coincidental with dry years and an increase in water utilization, a continuous lowering of water levels occurred, reaching its greatest average depth in the fall of 1950. There was some recovery of water levels in 1951, and recent data indicates that additional recovery in the Forebay Zone occurred in 1952 and 1953. Although there has been a rise in ground water levels in the Forebay Zone of North Santa Clara Valley, there has not been a corresponding rise of water levels in the Pressure Zone of the northern valley. This is shown on Plate 12,

TABLE 12
MEASURED FALL DEPTHS TO GROUND WATER AT REPRESENTATIVE WELLS IN SANTA CLARA VALLEY
(In feet)

Year	North Santa Clara Valley							South Santa Clara Valley				
	Pressure Zone			Forebay Zone				Pressure Zone		Forebay Zone		
	6S/1W-32Q1	6S/1E-30M1	7S/1W-2G1	7S/1W-35C1	7S/2W-3K1	7S/2E-17M1	8S/1E-5N1	10S/3E-13R1	11S/4E-6B1	9S/3E-27C2	10S/3E-1N1	11S/3E-1A2
1914.....	----	----	----	----	----	----	----	----	----	43.6	25.0	----
1915.....	----	----	----	107.0	----	----	----	----	----	----	----	----
16.....	----	----	----	93.0	----	----	----	----	----	----	----	----
17.....	----	----	----	----	----	----	----	----	----	50.8	----	----
18.....	----	----	----	122.0	----	----	----	----	----	----	----	----
19.....	----	----	----	----	145.2	----	----	----	----	65.0	----	----
1920.....	----	----	21.7	141.6	159.0	----	81.8	----	----	----	----	----
21.....	----	----	----	----	156.0	----	----	----	----	----	----	----
22.....	----	----	----	----	159.7	----	----	----	----	----	----	----
23.....	----	----	----	----	161.8	----	----	----	----	----	----	----
24.....	----	----	----	----	184.0	----	----	----	----	----	----	----
1925.....	----	----	----	----	193.6	----	----	----	----	----	----	----
26.....	----	----	----	----	192.5	----	----	----	----	----	----	----
27.....	----	----	----	----	188.2	----	----	----	----	----	----	----
28.....	----	----	----	----	196.5	----	----	----	----	----	----	----
29.....	----	----	----	----	217.0	----	----	----	----	----	----	----
1930.....	77.4	37.0	61.5	182.0	229.0	128.8	118.3	----	----	----	----	----
31.....	102.2	46.8	84.9	203.0	236.0	151.6	149.4	----	----	----	----	----
32.....	90.0	47.1	71.8	194.0	238.0	137.6	120.2	----	----	----	----	----
33.....	96.7	54.2	78.9	208.0	249.5	143.3	138.7	----	42.0	----	----	----
34.....	104.8	62.4	86.2	212.0	245.9	157.2	139.1	----	37.0	----	----	----
1935.....	113.4	70.2	86.2	194.0	249.1	160.6	103.9	----	36.0	105.0	----	----
36.....	127.0	78.9	90.2	200.0	246.5	170.5	104.5	----	30.0	100.0	----	----
37.....	108.3	50.2	82.5	186.0	231.2	181.0	53.7	----	31.0	----	----	----
38.....	87.1	37.1	52.4	155.0	197.5	138.2	40.6	----	24.0	50.0	----	----
39.....	102.5	39.3	69.3	185.0	222.8	160.0	103.8	----	----	81.0	----	----
1940.....	88.6	25.3	55.6	157.0	201.2	156.2	48.7	40.9	----	63.0	----	48.0
41.....	54.1	5.4	31.8	136.0	170.0	154.9	32.6	30.0	----	43.0	28.0	45.0
42.....	----	----	15.9	120.0	----	----	----	31.1	----	----	32.0	42.0
43.....	33.6	4.3*	20.9	138.0	162.7	141.7	37.5	----	----	----	38.0	----
44.....	48.0	4.5	35.4	151.0	182.0	149.9	42.9	42.7	31.0	----	50.0	60.0
1945.....	87.0	27.0	45.9	158.0	193.2	152.3	63.0	47.0	----	77.0	57.0	70.0
46.....	70.0	17.2	58.2	171.0	203.5	169.0	93.0	58.8	----	87.5	70.0	95.0
47.....	55.0	62.0	74.0	198.0	228.0	169.0	117.7	68.0	----	101.5	86.0	----
48.....	110.4	82.0	102.1	229.0	----	220.5	139.6	84.2	----	125.6	93.0	65.0
49.....	103.0	102.0	109.8	224.0	261.7	220.0	111.0	88.8	----	134.5	107.0	73.0
1950.....	142.1	----	122.9	243.0	252.7	235.6	151.8	104.0	68.0	142.0	113.0	80.0
51.....	134.7	117.5	138.8	236.0	----	----	111.6	90.0	----	128.4	----	----
52.....	----	----	----	216.0	----	----	----	65.4	----	----	72.0	54.0
53.....	140.3	87.4	110.9	216.0	----	----	102.4	----	----	107.4	----	----

* Flowing.

entitled "Lines of Equal Change in Ground Water Elevations, Fall of 1948 to Fall of 1953."

In South Santa Clara Valley ground water levels rose to a high point in 1938, declined in 1939, and again rose to a maximum in 1943. In that year the estimated average depth to ground water was the least during the period from 1932 through 1953. Following 1943, coincidental with dry years and an increase in water utilization, a continuous lowering of water levels occurred, reaching its greatest average depth in the fall of 1950.

In order to estimate weighted average changes in ground water elevations in the Santa Clara Valley during the selected base periods and each investigational season, maps were drawn showing lines of equal

change in ground water elevations during these periods. An example of these maps is presented as Plate 13, entitled "Lines of Equal Change in Ground Water Elevations in North Santa Clara Valley, Fall of 1935 to Fall of 1948." By planimetry the areas between lines of equal change, the weighted average change in elevation of ground water levels was estimated. The results of these estimates are presented in Table 14.

Change in Ground Water Storage

In an area of free ground water, the volume of soil unwatered or resaturated over a period of time, when multiplied by its specific yield, measures the change in ground water storage during that time. Available

TABLE 13

ESTIMATED AVERAGE FALL DEPTHS TO GROUND WATER
IN FOREBAY ZONES OF SANTA CLARA VALLEY

(In feet)

Year	North Santa Clara Valley	South Santa Clara Valley	Year	North Santa Clara Valley	South Santa Clara Valley
1932-----	102	67	1941-----	64	37
33-----	108	72	42-----	56	34
34-----	109	74	43-----	60	32
			44-----	72	40
1935-----	105	68	1945-----	84	48
36-----	103	68	46-----	95	58
37-----	94	60	47-----	107.1	68.0
38-----	79	42	48-----	114.4	75.3
39-----	91	52	49-----	123.3	81.8
1940-----	79	47	1950-----	139.6	92.5
			51-----	123.9	79.9
			52-----	113.0	73.2
			53-----	101.8	64.9

data on fluctuations of water levels at wells in forebay zones of the Santa Clara Valley were sufficient to estimate the volume of soil unwatered or resaturated during the base periods, and during the investigational and following seasons. Changes in ground water storage were estimated for each of the forebay zones by multiplying changes in elevations of ground water, presented in Table 14, by the area of each of the zones and by the average values of specific yield determined for each of the zones. The results of these estimates are presented in Table 15.

The estimates presented in Table 15 indicate that an average seasonal decrease in ground water storage in North Santa Clara Valley of about 4,500 acre-feet occurred during the 13-year base period, in which conditions of water supply and climate were approximately equivalent to conditions during the mean period. The estimated decrease in ground water storage during the period from 1947-48 through 1949-50 totaled approximately 208,000 acre-feet. However, for the period from 1950-51 through 1952-53 there was a recovery of about 242,000 acre-feet. An average seasonal decrease in ground water storage in South Santa Clara Valley of about 900 acre-feet occurred during the 16-year base period, in which conditions of water supply and climate were approximately equal to conditions during the mean period. The estimated decrease in ground water storage during the period from 1947-48 through 1949-50 totaled approximately 42,000 acre-feet. However, for the period from 1950-51 through 1952-53 there was a recovery of about 47,800 acre-feet.

Land Subsidence

The Ground Water Branch of the United States Geological Survey is making a continuing study of the rate, magnitude, and causes of land surface subsidence in North Santa Clara Valley. This study was initiated during the early 1930s by C. F. Tolman, since deceased, and J. F. Poland of Stanford University, presently with the United States Geological Survey.

TABLE 14

ESTIMATED WEIGHTED AVERAGE SEASONAL CHANGES IN FALL GROUND WATER
ELEVATIONS IN FOREBAY ZONES OF SANTA CLARA VALLEY

(In feet)

Division	1935-36 to 1947-48	1932-33 to 1947-48	1947-48	1948-49	1949-50	1950-51	1951-52	1952-53
North Santa Clara Valley-----	-0.7	----	-7.3	-8.9	-16.3	+15.7	+10.9	+11.2
South Santa Clara Valley-----	----	-0.5	-7.3	-6.5	-10.7	+12.6	+6.7	+8.3

TABLE 15

ESTIMATED WEIGHTED AVERAGE SEASONAL CHANGES IN GROUND WATER
STORAGE IN FOREBAY ZONES OF SANTA CLARA VALLEY

(In acre-feet)

Division	Area in acres	1935-36 to 1947-48	1932-33 to 1947-48	1947-48	1948-49	1949-50	1950-51	1951-52	1952-53
North Santa Clara Valley-----	86,500	-4,500	----	-46,700	-57,000	-104,300	+100,500	+69,800	+71,700
South Santa Clara Valley-----	26,600	----	-900	-12,600	-11,200	-18,500	+21,800	+11,600	+14,400

A bench mark network was laid out in 1933, in cooperation with the United States Coast and Geodetic Survey, to determine the extent and amount of subsidence in the vicinity of San Jose. Between 1933 and the spring of 1940, the network was releveled ten times by the Coast and Geodetic Survey, and was releveled again in the winter of 1948 and in the summer of 1954.

The rate of land subsidence was not uniform over the area. In Sunnyvale, which was the point of greatest subsidence during the base period, the decrease in ground surface elevation was about 0.9 foot from the spring of 1935 to December, 1937, and only 0.16 foot from December, 1937 to December, 1939. The indicated subsidence from December, 1939 to February, 1948 was 0.42 foot.

The Geological Survey has made a study for determination of the magnitude of subsidence that occurred from the spring of 1935 to the winter of 1948. Observed elevations of the Coast and Geodetic Survey were utilized to estimate subsidence. Contours of equal subsidence were drawn, and the volume lying between the ground surface in 1935 and that in 1948 was ascertained. The volume so determined was estimated at 52,000 acre-feet. Thus, the average rate of subsidence during the period was about 4,000 acre-feet per year.

The hydrostatic pressure on aquifers overlain by clays was substantially reduced during the base period. It has been suggested that, with reduced hydrostatic pressure and large weight of overlying material, these clays were reduced in volume, which in turn was reflected in land subsidence. It has been assumed that this reduction in volume of the clays was accompanied by yield of the water of compaction which filled the interstices between particles of clay, equal in volume to that of the land subsidence. Thus, the average rate of yield of the water of compaction during the base period was about 4,000 acre-feet per year.

The releveing in the summer of 1954 by the United States Coast and Geodetic Survey showed that the maximum subsidence had amounted to as much as 2.5 feet since 1948. This, when compared with the maximum subsidence of 1.7 feet during the base period, indicated that subsidence is continuing at an accelerated rate. The subsidence occurring during the two periods from 1935 to 1948 and from 1948 to 1954, is shown on Plate 14, entitled "Lines of Equal Subsidence of Ground Surface in North Santa Clara Valley for the Periods 1934-1948 and 1948-1954." This plate was plotted from U. S. Coast and Geodetic Survey data.

Subsurface Inflow and Outflow

Subsurface inflow constitutes a part of the water supplies utilized in both North and South Santa Clara Valleys. Ground water inflow to North Santa

Clara Valley enters through pressure aquifers from beneath San Francisco Bay and from hills adjacent to the valley floor. South Santa Clara Valley receives small quantities of ground water inflow from adjacent hills, and from the northern end of the valley through sediments of the Coyote Creek alluvial cone.

The portion of the average seasonal subsurface inflow from beneath San Francisco Bay to the pressure zone of North Santa Clara Valley in 1946-47, 1947-48, 1948-49, and 1949-50, was estimated from the configuration of the piezometric surface of ground water in that zone, and from estimates of ground water extractions. During those seasons it was found that a trough existed in the piezometric surface of the ground water near the shore of San Francisco Bay. This trough condition is indicated on Plate 15, entitled "Lines of Equal Elevation of Ground Water in North Santa Clara Valley, September-October, 1953." From the basic hydraulic principle that flow of water occurs in the downward direction of the slope of the hydraulic gradient, it follows that all pumping on the bay side of the trough is supplied by inflow from the direction of the bay. Average seasonal pumping draft during the aforementioned three seasons was estimated from the area of irrigated crops, urban area, and miscellaneous areas in the pressure zone lying between the mean position of the ground water trough and San Francisco Bay, and from average application of water to these areas, determined from studies conducted during the investigation. The average seasonal subsurface inflow so determined from 1947-48 through 1949-50 was about 9,200 acre-feet. During the base period, beginning in 1934-35 and ending in 1947-48, seasonal subsurface inflow from under San Francisco Bay probably varied in amount and direction of flow, depending upon ground water elevations in the forebay zone, pattern and amount of pumping, and other variables. The estimated average subsurface inflow from beneath San Francisco Bay during the 13-year base period was about 8,000 acre-feet per season. This estimate was made by applying the ratio of the average ground water overdraft in the pressure zone during the base period, and the overdraft in the pressure zone in 1947-48, both of which are discussed later, to average subsurface inflow from beneath the bay during the period from 1947-48 through 1949-50.

Subsurface outflow from North Santa Clara Valley occurs through sediments of the Coyote Creek cone to South Santa Clara Valley, as hereinafter discussed. The 13-year base period seasonal average of subsurface outflow from the northern valley from the Coyote Creek cone was estimated to have been about 2,400 acre-feet, and the mean seasonal value about 2,700 acre-feet.

Lines of equal elevation of ground water shown on Plate 10 indicate that subsurface inflow to South Santa Clara Valley occurs from the Coyote Creek

cone. The amount of this inflow was estimated from total percolation occurring in the nine-mile reach of Coyote Creek from the Upper to the Lower Gorge. From the shape of ground water contours on the Coyote Creek cone, it was estimated that about 1.8 miles of the nine-mile reach supplies percolating waters to South Santa Clara Valley. Assuming percolation over the nine-mile reach is constant, about 20 per cent of the total percolation is tributary to the southern valley. Presented in Table 16 are seasonal quantities of estimated inflow to South Santa Clara Valley for the 16-year period from 1932-33 to 1947-48, inclusive. The average seasonal subsurface inflow for this period was about 2,400 acre-feet. Mean subsurface inflow was estimated by multiplying the base period average by the ratio of the 53-year mean to the 16-year average surface inflow in Coyote Creek, and amounted to about 2,700 acre-feet per season.

TABLE 16

ESTIMATED SUBSURFACE FLOW FROM COYOTE CREEK CONE TO SOUTH SANTA CLARA VALLEY

(In acre-feet)

Season	Percolation loss, Upper to Lower Gorge	Subsurface flow
1932-33.....	5,120	1,020
33-34.....	6,900	1,380
1934-35.....	15,700	3,140
35-36.....	24,150	4,830
36-37.....	12,630	2,530
37-38.....	16,130	3,230
38-39.....	6,170	1,230
1939-40.....	11,010	2,200
40-41.....	6,960	1,390
41-42.....	13,140	2,630
42-43.....	15,950	3,190
43-44.....	15,850	3,170
1944-45.....	18,870	3,770
45-46.....	11,700	2,340
46-47.....	6,000	1,200
47-48.....	3,600	720
TOTALS.....	189,880	37,970
AVERAGES.....	11,900	2,400

Piezometric ground water contours indicate that subsurface outflow from South Santa Clara Valley across its southern boundary, the Pajaro River, is small. This value, therefore, was neglected in the hydrologic studies. Ground water overlying the pressure zone at the lower end of the southern valley probably rises in the channel of the Pajaro River and leaves the valley as surface outflow.

Base period subsurface inflow from hills of the pervious Santa Clara formation, adjacent to the floor of the Santa Clara Valley, was estimated by an indirect method. This involved evaluation of subsurface inflow from adjacent hills as the item necessary to effect a balance between water supply and disposal. The sum of the items comprising the water supply of

a given hydrologic unit or area must be equal to the sum of the items of water disposal. In the Santa Clara Valley values of water supply and disposal, other than subsurface inflow from adjacent hills, were quantitatively measured or estimated. Subsurface inflow from the adjacent hills was the remaining unknown quantity to balance supply and disposal. Table 17 sets forth this equation during the respective base periods for North and South Santa Clara Valleys. Determination of the values of use of water shown in Table 17 is explained in Chapter III.

TABLE 17

ESTIMATED AVERAGE SEASONAL SUBSURFACE INFLOW FROM ADJACENT HILLS IN NORTH AND SOUTH SANTA CLARA VALLEYS DURING RESPECTIVE BASE PERIODS

(In acre-feet)

Item	North Santa Clara Valley	South Santa Clara Valley
Water Supply		
Precipitation on Forebay Zone.....	145,600	60,400
Surface inflow to Forebay Zone.....	207,500	57,100
Decrease in ground water storage.....	4,500	900
Water of compaction.....	4,000	
Subsurface inflow other than from adjacent hills.....	8,000	2,400
Import.....	2,000	
TOTALS.....	371,600	120,800
Water Disposal		
Surface outflow from Forebay Zone.....	111,300	49,000
Subsurface outflow.....	2,400	
Consumptive use of water in Forebay Zone.....	183,900	53,400
Applied water in Pressure Zone.....	90,200	23,900
TOTALS.....	387,800	131,300
REMAINDER-SUBSURFACE INFLOW FROM ADJACENT HILLS.....	16,200	10,500

The estimates of seasonal subsurface inflow from hills adjacent to the Santa Clara Valley shown in Table 17 were also utilized as mean seasonal values, since the water supplies available during the selected base periods closely approached mean seasonal values of water supply.

High Water Table Areas

During the investigational seasons it was found that drainage was not a serious problem in the Santa Clara Valley, except on lands adjacent to the tidal marshes of San Francisco Bay in North Santa Clara Valley, and near the Pajaro River in South Santa Clara Valley. The drainage problems experienced in prior years have improved, probably due to lowering of ground water levels and to the series of dry years following 1942.

United States Geological Survey Water-Supply Paper 519, published in 1924, reported the existence of a swamp east of San Jose, which "probably owes its origin to the building of the alluvial fans of Coyote Creek and Penitencia Creek on opposite sides

of it. The finer materials deposited on the margin of the Penitencia fan probably tend to obstruct the movement of the ground water percolating from Dry Creek and thus bring it to the surface in the swamp." Improved drainage, resulting from the straightening and improvement of the Silver Creek channel, has since made possible the reclamation of this swamp.

Water-Supply Paper 519 also reported on the existing Lake Laguna Seco and adjoining swampy lands at the northern end of Coyote Valley and stated that they "owe their origin to the fact that the area occupied by them is lower than the land nearer Coyote Creek and to the fact that the projection of hard rock nearly across the valley west of them stops the progress of ground water and forces it to rise. A small intermittent stream (Fisher Creek) discharges into this swampy tract, but its flow is probably not sufficient during the dry season to supply more than part of the water that evaporates from the lake and swamp . . . it is believed that most of the water of the lake and swamp is ground water supplied by percolation from Coyote Creek farther up the fan." Construction of a drainage canal has improved this condition, and the construction of the Coyote Canal has further helped to relieve it by reducing percolation on the Coyote Creek cone.

The Morgan Hill and San Juan Bautista Quadrangles of the United States Geological Survey, surveyed in 1915, show a fresh-water marsh of considerable extent along Llagas Creek, beginning east of Gilroy and extending south to Bloomfield Avenue, and a smaller fresh-water marsh about two miles north of Sargent. Although drainage of these areas has been improved in recent years by construction of drainage works, there is evidence that high water levels occasionally prevail. This is evidenced by small patches of tules, water grass, low water use by crops indicating subirrigation, and areas where water stands for some time following irrigation, floods, or rains. The constriction of the Pajaro River near Sargent by impervious formations of the Santa Cruz Range restricts drainage in the southernmost portion of Santa Clara County. Thus, the area lying between Llagas Creek and the foothills of the Santa Cruz Range, and between Gilroy and Sargent, is subject to high ground water, the source of which may consist of one or more of the following: percolation of rainfall on the area, natural percolation from Llagas and Carnadero Creeks which occurs over the pressure zone, flooding from Llagas and Carnadero Creeks, subsurface inflow from the free ground water zone at times when the water surface in that zone is above the confining aquifers, deep percolation from irrigation in the area, and contributions from the pressure aquifers through old casings perforated in both the pressure aquifers and overlying ground water zones.

Safe Ground Water Yield

The term "safe ground water yield" refers to the maximum rate of extraction of water from a ground water body which, if continued over an indefinitely long period of years, would result in the maintenance of certain desirable fixed conditions. Commonly, safe ground water yield is determined by one or more of the following criteria:

1. Water levels are not so lowered as to imperil the economy of ground water users by excessive costs of pumping from the ground water basin, or by exclusion of users from a supply therefrom.
2. Mean seasonal extraction of water from the ground water basin does not exceed mean seasonal replenishment to the basin.
3. Water levels are not so lowered as to cause harmful impairment of the quality of ground water by intrusion of other water of undesirable quality, nor by accumulation and concentration of degradants or pollutants.

Under the present pattern of water use in the Santa Clara Valley, average pumping lifts, while large in certain areas, have resulted in no widespread local concern regarding costs of pumping. The lack of any special concern probably arises from the fact that, at least in North Santa Clara Valley, much of the recent development has been urban in nature and able to carry larger pumping costs than if such development had been mostly agricultural. For this reason it was considered that only the second and third of the foregoing criteria were of significance in this instance. The second criterion was considered applicable to determination of safe yield in the forebay zones of North and South Santa Clara Valley, while the third criterion was utilized for determination of safe yield in the pressure zones.

Forebay Zones. Safe ground water yield of the forebay zones of North and South Santa Clara Valley, as derived in this bulletin, was measured by net extraction of water from the ground water basins, as differentiated from total pumpage from these basins. From irrigated lands overlying the free ground water bodies of the Santa Clara Valley, most of the unconsumed portion of the total pumpage of water returns to the ground water body and becomes available for re-use. However, such unconsumed portion in the pressure zones wastes from the valley and is not available for re-use. The net rate of extraction of ground water, therefore, was considered to be the total pumpage in the pressure zones plus that portion of the pumpage from the ground water basin in the forebay zones which was consumptively used.

Under natural conditions, ground water is expended by consumptive use from seep lands and from lands where the water table is close to the ground surface, by effluent stream flow, and by subsurface outflow.

Artificial development and utilization of ground water salvages all or a portion of such natural disposal, by lowering ground water levels. As wells are drilled and pumped, unconfined ground water levels are lowered, salvaging water lost in uneconomic consumption, and providing storage space to conserve surplus waters.

Under present conditions of water utilization in North and South Santa Clara Valleys, the extraction of water from the ground water basins in both these areas exceeds the safe yields therein. This condition also prevailed during the respective base periods.

Estimates of the net seasonal draft on ground water during the respective base period for North and South Santa Clara Valleys are presented in Chapter III. After correction of these estimates for differences between mean and base period values for percolation, precipitation, change in ground water storage, yield of water of compaction, and subsurface inflow from beneath San Francisco Bay, the seasonal safe ground water yield was estimated. These estimates are presented in Table 18.

TABLE 18

**ESTIMATED SAFE MEAN SEASONAL GROUND WATER
YIELD OF FOREBAY ZONES OF SANTA
CLARA VALLEY**

(In acre-feet)

Item	North Santa Clara Valley	South Santa Clara Valley
Average net draft on ground water during base period	154,800	41,600
Difference between average base period percolation and mean percolation	-1,300	1,000
Difference between average base period precipitation and mean precipitation	-1,400	-2,400
Average base period change in ground water storage	-4,500	-900
Average base period yield of water of compaction	-4,000	0
Average base period subsurface inflow from beneath San Francisco Bay	-8,000	
Difference between average base period and present subsurface inflow from beneath San Francisco Bay	-1,200	
SAFE SEASONAL GROUND WATER YIELD	134,400	39,300

Pressure Zones. With regard to the third of the stated criteria for determination of safe yield, it was found that in the Pressure Zone of North Santa Clara Valley a rate of ground water extraction from the confined aquifers has been reached sufficient to induce intrusion of water from beneath San Francisco Bay. During periods of heavy pumping draft in summer months, the elevation of the hydraulic gradient in the confined aquifers is depressed below sea level near the bay, resulting in a threat of degradation of the water supply by sea-water intrusion from the bay. This trough condition results from the inadequacy of the confined aquifers in the Pressure Zone to convey water from the Forebay Zone at rates sufficient to meet the rate of draft in the Pressure Zone. For this

reason the third of the foregoing criteria was adopted for determination of safe ground water yield in the Pressure Zone of North Santa Clara Valley. The limit of safe ground water yield was defined as that maximum rate of pumping extraction from the Pressure Zone beyond which the hydraulic gradient in the confined aquifers would not be depressed below mean sea level.

Fluctuations in water levels in a free ground water body indicate changes in ground water storage, since these levels represent the true ground water surface. In contrast, fluctuations of water levels in a confined ground water body reflect only variations in the piezometric surface elevation, or pressure head, and do not indicate changes in ground water storage unless the water surface drops below the impervious strata overlying the aquifers. In the Pressure Zone of North Santa Clara Valley the piezometric surface elevation remained above the confining clays throughout the period of investigation.

The yield of water-bearing formations in a confined ground water body is dependent both on the capacity of the aquifers to conduct water from the forebay, and on the hydraulic gradient from the forebay through the confined ground water body. The hydraulic gradient, in turn, is influenced by the areal extent, storage capacity, and seasonal recharge of the forebay, and by draft from aquifers in the confined ground water body.

Based on well measurements made during the season of 1946-47, it was found that a trough condition, in which the elevation of the hydraulic grade line was depressed below sea level, occurred in the Pressure Zone of North Santa Clara Valley during the summer months. In 1946-47 the trough first appeared near the bay about June 1st, moving slightly inland and deepening as the pumping season progressed. The trough receded as pumping draft decreased in the fall, but, based on available measurements of depth to ground water, it has failed to disappear up to the present time. Prior to 1946-47, and during the base period, data indicate that in each year a trough condition existed at the height of the season of heavy draft. However, as the draft decreased the trough would disappear. During each season of the period from 1946-47 through 1953-54, the most inland position of the trough was generally in the same location. The trough generally extended inland from the bay to Palo Alto, Mountain View, Sunnyvale, and between Milpitas and Alviso. In connection with a water resource investigation being conducted in Alameda County by the Division of Water Resources, it was found that the trough continued in the fall of 1953 from North Santa Clara Valley into Alameda County as far north as San Lorenzo. In 1947-48, the maximum depth of the trough in North Santa Clara Valley was 70 feet below mean sea level. In April and September of 1953, the trough had reached a depth of 60 and 100 feet

below sea level, respectively. A ground water map was prepared showing elevations of the pressure surface in the Pressure Zone of North Santa Clara Valley, near the time of the maximum trough condition. This map is included as Plate 15, entitled "Lines of Equal Elevation of Ground Water in North Santa Clara Valley, September-October, 1953."

A typical trough condition in the Pressure Zone of North Santa Clara Valley is also illustrated on Plate 8, which shows the indicated relationships of the Forebay Zone and San Francisco Bay to the confined aquifers of the Pressure Zone. Formation of the trough in the Pressure Zone indicates that the rate of pumping extraction from the confined aquifers, during the months of heavy draft, exceeds the rate at which the aquifers could convey water from the Forebay Zone under conditions of safe yield as previously defined. Also, intrusion of water from beneath San Francisco Bay in the confined aquifers is indicated by the hydraulic gradient from the bay inland to the trough. Since ground water flows in the direction of the hydraulic gradient, it is evident that pumping draft between the bay and the trough must be supplied by flow of water through the confined aquifers from the direction of San Francisco Bay. Similarly, pumping draft on the inland side of the trough must be furnished by flow down the aquifers from the direction of the Forebay Zone.

It will be noted that Plate 8 also illustrates a position of the hydraulic grade line with rate of pumping draft equal to or less than the safe yield of the confined aquifers. Under this safe yield condition, the elevation of the hydraulic grade line would never be depressed below mean sea level, and the only source of flow in the confined aquifers would be from the Forebay Zone.

In light of the foregoing, the rate of safe ground water yield in the Pressure Zone of North Santa Clara Valley was derived by estimating the rate of flow from the Forebay Zone through the confined aquifers immediately prior to existence of a trough. Since the Forebay Zone is the only source of ground water to the confined aquifers under conditions of safe yield, the rate of pumping draft from the aquifers under these conditions would equal the flow in the aquifers. As was stated, during the 1946-47 season a ground water trough first appeared about June 1st. Thus, the draft prior to June 1st was met entirely by water supplied from the forebay. It was estimated that the monthly draft on ground water at that time was about 11,000 acre-feet, or a continuous flow at the rate of about 182 second-feet.

Based on the previously cited studies of application of water in the Pressure Zone of North Santa Clara Valley, it was estimated that the rate of pumping draft at the peak of the 1948 season was about 286 second-feet. Rates of pumping draft during the 1948

season, therefore, were substantially greater than the estimated safe yield of 182 second-feet. It is indicated that the portion of pumping draft in excess of safe yield is supplied by flow from beneath San Francisco Bay and by the increased flow from the Forebay Zone induced by the steepening of the hydraulic gradient beyond that prevailing under conditions of safe yield.

Studies indicated that the rate of pumping draft at the peak of the 1948 pumping season exceeded that for safe yield by about 104 second-feet. In terms of quantity, and based on these rates, it was estimated that the total draft exceeded safe yield by about 20,000 acre-feet in 1947-48. Of this value it was estimated that about 9,200 acre-feet constituted intrusion of water from beneath San Francisco Bay, and about 10,800 acre-feet was furnished by increased inflow down the aquifers from the Forebay Zone, induced by the steepened hydraulic gradient beyond the safe yield gradient.

On the basis of studies of application of water, as derived in Chapter III, the estimated total pumpage from the confined aquifers of the Pressure Zone of North Santa Clara Valley was about 104,300 acre-feet in 1947-48. Based on derived rates of flow in the confined aquifers, pumping draft exceeded safe ground water yield by an estimated 20,000 acre-feet in 1947-48. Therefore, under the present pattern of draft, safe ground water yield of the confined aquifers serving the Pressure Zone of North Santa Clara Valley was estimated to be about 84,300 acre-feet per season.

Piezometric ground water measurements made in the Pressure Zone of South Santa Clara Valley near the Pajaro River during the investigation indicated that no ground water troughs were formed during periods of maximum pumping draft. However, the measurements showed that hydraulic gradients during such periods were fairly flat, indicating that the safe yield of the confined aquifers may have been nearly reached. As derived in Chapter III on the basis of studies of application of water, the estimated maximum monthly pumpage from the confined aquifers of the Pressure Zone of South Santa Clara Valley was about 5,100 acre-feet, or a continuous flow equivalent to about 85 second-feet. This rate was considered to approximate the safe ground water yield of the Pressure Zone of South Santa Clara Valley. The safe yield of the Pressure Zone, on a quantitative basis, and under the present pattern of draft, was, therefore, considered to equal the 1947-48 pumping draft of 26,600 acre-feet per season.

QUALITY OF WATER

The surface and ground water supplies of the Santa Clara Valley are generally of excellent mineral quality, and well suited from this standpoint for irrigation and other beneficial uses. However, in certain

limited areas in the eastern portion of North Santa Clara Valley the ground water is unfit for prolonged irrigation use because of its high concentration of certain mineral constituents. Ground water of questionable quality also occurs on the fringe of the tideland area adjacent to San Francisco Bay. The principal objectives of the water quality investigation, therefore, were to evaluate these conditions, and to determine the extent of the area presently affected by poor quality water and the source or sources of such water.

It is desirable to define certain terms commonly used in connection with discussion of quality of water:

Quality of Water—Those characteristics of water affecting its suitability for beneficial uses.

Mineral Analysis—The quantitative determination of inorganic impurities or dissolved mineral constituents in water.

Degradation—Impairment of the quality of water due to causes other than disposal of sewage and industrial wastes.

Contamination—Impairment of the quality of water by sewage or industrial waste to a degree which creates a hazard to public health through poisoning or spread of disease.

Pollution—Impairment of the quality of water by sewage or industrial waste to a degree which does not create a hazard to public health, but which adversely and unreasonably affects such water for beneficial uses.

Hardness—The characteristic of water which causes curdling of soap, increased consumption of soap, deposition of scale on boilers, injurious effects in some industrial processes, and sometimes objectionable taste, and which is due in large part to the presence of salts of calcium, iron, and magnesium.

Complete mineral analysis included a determination of three cations, consisting of calcium, magnesium, and sodium; four anions, consisting of bicarbonate, chloride, sulphate, and nitrate; total soluble salts; boron; and computation of per cent sodium. Partial analysis included determination of chlorides and total mineral solubles only.

With the exception of boron, the concentrations of cations and anions in a water sample are expressed in this bulletin in terms of "equivalents per million." This was done because ions combine with each other on an equivalent basis, rather than on a basis of weight, and a chemical equivalent unit of measurement provides a better and more convenient expression of concentration. This is especially true when it is desired to compare the composition of waters having variable concentrations of mineral solubles. In the case of boron, concentrations are expressed on a weight basis of "parts per million" of water. In order to convert equivalents per million to parts per million,

the concentration, expressed in equivalents per million, should be multiplied by the equivalent weight of the cation or the anion in question. Equivalent weights of the common cation and anions are presented in the following tabulation:

Cation	Equivalent weight	Anion	Equivalent weight
Calcium -----	20.0	Bicarbonate ----	61.0
Magnesium -----	12.2	Chloride -----	35.5
Sodium -----	23.0	Sulphate -----	48.0
		Nitrate -----	62.0

Data used to determine the quality of water in the Santa Clara Valley included complete mineral analyses of 19 surface water samples, and complete mineral analyses of ground water samples collected from 59 wells. The data also included partial mineral analysis of water samples collected from 297 wells during the investigation. Results of these partial analyses are presented in Appendix G. Other data used during the course of the investigation included chloride analyses of water samples collected from 337 wells in 1938-39. These analyses were furnished by J. F. Poland of the United States Geological Survey.

Standards of Quality for Water

Investigation and study of the quality of surface and ground waters of the Santa Clara Valley, as reported herein, were largely limited to consideration of mineral constituents of the waters, with particular reference to their suitability for irrigation use. However, it may be noted that, within the limits of analyses herein reported, a water which is determined to be suitable for irrigation may also be considered as being either generally suitable for municipal and domestic use, or susceptible to such treatment as will render it suitable for that purpose.

The major criteria which were used as a guide to judgment in determining suitability of water for irrigation use comprised the following: (1) chloride concentration, (2) total soluble salts, (3) boron concentration, and (4) per cent sodium.

1. The chloride anion is usually the most troublesome element in irrigation waters. It is not considered essential to plant growth, and excessive concentrations will inhibit growth.

2. Total soluble salts furnishes an approximate indication of the over-all mineral quality of water. It may be approximated by multiplying specific electrical conductance ($Ec \times 10^6$ at $25^\circ C.$) by 0.7. The presence of excessive amounts of dissolved salts in irrigation water will result in reduced crop yields.

3. Crops are sensitive to boron concentration, but require a small amount, less than 0.1 part per million, for growth. They will usually not tolerate more than 0.5 to 2 parts per million, depending on the crop in question.

4. Per cent sodium reported in the analyses is the proportion of the sodium cation to the sum of all cations, and is obtained by dividing sodium by the

sum of calcium, magnesium, and sodium, all expressed in equivalents per million, and multiplying by 100. Water containing a high per cent sodium has an adverse effect upon the physical structure of the soil by dispersing the soil colloids and making the soil "tight," thus retarding movement of water through the soil, retarding the leaching of salts, and making the soil difficult to work.

The following excerpts from a paper by Dr. L. D. Doneen, of the Division of Irrigation of the University of California at Davis, may assist in interpreting water analyses from the standpoint of their suitability for irrigation:

"Because of diverse climatological conditions, crops, and soils in California, it has not been possible to establish rigid limits for all conditions involved. Instead, irrigation waters are divided into three broad classes based upon work done at the University of California, and at the Rubidoux, and Regional Salinity Laboratories of the United States Department of Agriculture.

"Class 1. EXCELLENT TO GOOD—Regarded as safe and suitable for most plants under any condition of soil or climate.

"Class 2. GOOD TO INJURIOUS—Regarded as possibly harmful for certain crops under certain conditions of soil or climate, particularly in the higher ranges of this class.

"Class 3. INJURIOUS TO UNSATISFACTORY—Regarded as probably harmful to most crops and unsatisfactory for all but the most tolerant.

"Tentative standards for irrigation waters have taken into account four factors or constituents, as listed below.

<i>Factor</i>	<i>Class 1 Excellent to Good</i>	<i>Class 2 Good to Injurious</i>	<i>Class 3 Injurious to Unsatisfactory</i>
Conductance ($E_c \times 10^6$ @ 25° C.)	Less than 1000	1000-3000	More than 3000
Boron, ppm	Less than 0.5	0.5-2.0	More than 2.0
Per cent sodium	Less than 60	60-75	More than 75
Chloride, epm	Less than 5	5-10	More than 10

(end of quotation)

Hardness of water is caused principally by compounds of calcium and magnesium, although other mineral constituents such as iron, manganese, aluminum, barium, silica, and strontium, may contribute to the hardness. In this bulletin total hardness is expressed in parts per million in terms of calcium carbonate hardness. It was computed by adding calcium and magnesium, expressed in equivalents per million, and multiplying this sum by 50. Water having a total hardness of less than 50 parts per million is rated as soft water for nearly all purposes except the most exacting of industrial uses, and seldom requires treatment for reduction or elimination of hardness. Water having a range of total hardness up to 150 parts per

million is suitable for most household uses. However, in the case of such water, reduction of hardness by softening processes would reduce soap consumption and deposits of scale in plumbing systems, thus enhancing the suitability of the water for laundries and other industrial purposes. Where total hardness in water exceeds from 150 to 200 parts per million, water softening processes are usually resorted to in order to render the water more acceptable for domestic, municipal, and industrial uses. However, objections to hardness in water may depend on local opinion, and a water considered too hard in certain localities might be considered satisfactory in others.

Quality of Surface Water

Surface inflow to the Santa Clara Valley is generally of excellent mineral quality, and is well suited to irrigation and other uses. Surface waters are characterized by low concentrations of mineral solubles, low per cent sodium, and, with the exception of Penitencia Creek, low boron content. Penitencia Creek is the only stream of importance whose waters sometimes contain quantities of boron deleterious to plant growth. Boron in this stream originates principally from mineral springs in the vicinity of Alum Rock Park.

Water in streams draining the Santa Cruz Mountains on the west side of the Santa Clara Valley generally contain lower concentrations of mineral solubles than water in streams emanating from the Diablo Range on the east. Concentrations of total solubles in streams entering the valley floor from the west are in the order of about 200 parts per million, whereas those in east-side streams approximate 350 parts per million. This difference is due largely to greater dilution by higher runoff in west-side streams, and to the dissimilar composition of rocks in the two mountainous areas.

Analyses of representative surface waters collected from major surface streams entering the Santa Clara Valley are presented in Table 19. Results of determination of total hardness in water samples collected from representative streams of the Santa Clara Valley during 1949 are also presented in Table 19.

Quality of Ground Water

Mineral analyses of ground waters in the Santa Clara Valley indicate that such water supplies near the Santa Cruz Mountains are less saline than those near the Diablo Range, reflecting the aforementioned qualities of surface inflow. On the west side of North Santa Clara Valley, concentrations of mineral solubles in ground water are from about 300 to 400 parts per million, while on the east side concentrations are from about 700 to 800 parts per million. Wells near the Santa Cruz Mountains in South Santa Clara Valley yield water containing total solubles of about 275 parts per million, whereas those near mountains to

TABLE 19

COMPLETE MINERAL ANALYSES OF REPRESENTATIVE SURFACE WATERS IN SANTA CLARA VALLEY

Station	Date of sample	Total hardness, in ppm of CaCO ₃	Conductance, Ec×10 ⁶ at 25° C.	Boron, in ppm	Per cent sodium	Mineral constituents, in equivalents per million						
						Ca	Mg	Na	HCO ₃ +CO ₃	Cl	SO ₄	NO ₃
North Santa Clara Valley												
Penitencia Creek at Santa Clara Valley	2/11/49	160	448	1.45	40	1.80	1.49	2.19	3.61	0.88	1.09	0.06
Water Conservation District diversion	3/ 5/49	120	366	0.82	11	1.30	1.08	1.68	2.38	0.59	0.64	0.09
Dry Creek, 2.5 miles upstream from Evergreen School	3/24/49	310	641	0.08	23	2.29	3.88	1.81	5.14	1.16	1.74	0.09
Silver Creek, 1 mile above gage	3/ 5/49	340	658	0.07	21	0.98	5.83	1.83	6.04	1.51	0.62	0.13
Coyote Creek at Cochran Road	2/16/49	160	366	0.22	21	1.85	1.37	0.85	2.45	0.33	1.07	0.21
Coyote Creek at Alviso-Milpitas Road*	9/19/49	250	535	0.10	24	3.21	1.79	1.61	4.78	0.15	0.82	trace
Almaden Creek at McKean Road	2/ 8/49	160	288	0.07	15	1.20	2.05	0.56	2.84	0.19	0.42	trace
Guadalupe Creek at United States Geological Survey gage	2/ 8/49	140	261	0.12	13	1.25	1.52	0.40	2.39	0.22	0.48	trace
San Tomas Aquinas Creek at San Tomas	3/ 7/49	160	348	0.00	19	1.48	1.64	0.75	2.47	0.46	0.66	0.11
Los Gatos Creek, 0.4 mile upstream from Los Gatos	3/ 9/49	160	315	0.11	21	1.89	1.34	0.84	2.40	0.26	1.17	trace
Los Gatos Creek at Vasona Dam	3/ 7/49	140	310	0.05	21	1.55	1.27	0.75	2.12	0.29	0.90	0.09
Campbell Creek at Saratoga	3/ 9/49	150	320	0.16	19	2.03	1.08	0.73	2.44	0.35	0.92	trace
Stevens Creek at United States Geological Survey gage	3/ 9/49	200	376	0.13	16	2.57	1.36	0.77	3.34	0.43	0.80	trace
Permanente Creek at Loyola	3/ 9/49	430	807	0.00	18	4.99	3.64	1.91	6.48	1.93	1.79	0.10
San Francisquito Creek at Stanford golf course	2/16/49	110	286	0.09	38	1.24	0.97	1.34	1.34	0.64	0.95	0.26
South Santa Clara Valley												
Llagas Creek at Llagas Road	2/ 7/49	140	262	0.21	14	1.14	1.67	0.46	2.33	0.26	0.52	trace
Uvas Creek at Watsonville Road	2/ 7/49	100	192	0.00	18	0.93	0.98	0.42	1.58	0.20	0.44	trace
Carnadero Creek at Bloomfield Road	2/ 7/49	80	150	0.05	24	0.74	0.85	0.49	1.18	0.20	0.46	trace
Carnadero Creek at Sargents Ranch*	9/21/49	320	855	0.37	43	2.92	3.40	4.77	7.05	1.20	1.98	trace

* Irrigation drainage waters.

the east produce water having mineral constituents amounting to approximately 350 parts per million. It should be noted, however, that waters having the higher concentrations of dissolved solids are well within limits prescribed for good quality irrigation water.

It is apparent that mineral constituents present in ground waters of the Santa Clara Valley are dependent in part on constituents of the surface water supplies. Those originating from percolation of surface runoff from the Santa Cruz Mountains are predominantly of the calcic-bicarbonate type, and have relatively low concentrations of boron and per cent sodium. They are suitable for unrestricted irrigation use. Mineral properties of ground waters originating in the Diablo Range runoff vary more widely than those derived from west-side streams. These east-side waters are also chiefly of the calcic-bicarbonate type and are suitable for irrigation use. However, relatively high concentrations of boron in some ground waters of the Penitencia Creek cone, and high magnesium content of waters in a portion of the Silver and Dry Creek cones, render these ground waters in certain localities unfit for prolonged irrigation use. Ground waters of questionable quality also occur on the fringes of the tideland area adjacent to San Francisco Bay.

As described heretofore, the normal slope of the ground water hydraulic gradient in the North Santa Clara Valley pressure zone toward San Francisco

Bay has been reversed due to excessive lowering of ground water levels. Ground water supplying pumping draft in the pressure zone between the previously described ground water trough and the shore of San Francisco Bay flows through gravel deposits underlying the bay. Potential intrusion of saline water from the bay may be a threat to the quality of ground water in the Pressure Zone of North Santa Clara Valley, if the bay waters have access to the underlying pressure aquifers.

Under original conditions, ground water movement occurred from the free ground water bodies around the edges of the San Francisco Bay depression into the pressure aquifers which extended under the alluviated areas and finally under San Francisco Bay. Ground water movement was generally toward the bay from all its sides. The discharge of fresh water from the pressure aquifers beneath San Francisco Bay under original conditions must have been from these aquifers directly into the sea water of the bay. The points of discharge included all points where the aquifers were not protected by confining beds and were in direct contact with sea water of the bay. Early reports of boils of fresh water in San Francisco Bay were undoubtedly attributable to discharge of fresh water at such points.

The present situation of a ground water trough in the pressure zone of North Santa Clara Valley at an elevation considerably below sea level, indicates that the extension of the pressure surface beneath San

TABLE 20
COMPLETE MINERAL ANALYSES OF GROUND WATERS IN SANTA CLARA VALLEY

Well number	Depth, in feet	Use	Date of sample	Hard- ness, ex- pressed in ppm of Ca CO ₃	Con- duct- ance, Ec × 10 ⁶ at 25° C.	Boron, in ppm	Per cent so- dium	Mineral constituents, in equivalents per million						
								Ca	Mg	Na	HCO ₃ + CO ₃	Cl	SO ₄	NO ₃
NORTH SANTA CLARA VALLEY														
Pressure Zone														
5S/1W-36J1			9/20/49	270	562	0.16	23	3.66	1.75	1.59	4.83	0.76	1.04	Tr
5S/3W-35G1		Municipal	9/20/49	200	714	0.17	53	2.65	1.34	4.46	4.25	2.82	0.87	Tr
6S/1W-1P1		Irrigation	9/19/49	282	592	0.16	20	3.71	1.93	1.42	5.22	0.72	0.91	Tr
6S/1W-10P3		Irrigation	6/24/49	471	1123	0.09	31	4.40	5.02	4.31	6.62	3.66	3.37	Tr
6S/1W-11A1		Irrigation	6/ 2/49	242	637	0.09	34	3.00	1.85	2.53	5.45	1.31	0.61	Tr
6S/1W-12A1		Irrigation	6/ 8/49	289	621	0.06	22	3.71	2.07	1.65	5.67	0.75	0.93	Tr
6S/1W-15C2		Irrigation and domestic	6/24/49	968	2355	0.07	33	9.28	10.08	9.42	7.69	13.05	7.50	Tr
6S/1W-15F2		Irrigation	5/23/49	938	2325	0.17	34	9.14	9.61	9.53	8.82	11.38	7.15	Tr
6S/1W-17K1			9/19/49	436	1177	0.96	44	2.20	6.53	6.77	11.91	1.63	1.64	Tr
6S/1W-18L1		Irrigation	9/20/49	634	1563	1.04	37	5.60	7.07	7.54	10.45	3.19	3.78	1.54
6S/1W-22J1	815	Domestic	6/24/49	66	461	0.03	74	0.81	0.52	3.81	3.72	1.10	0.34	Tr
6S/1W-23J1	174	Irrigation	6/24/49	211	481	0.00	28	2.86	1.36	1.66	4.13	0.64	0.95	0.06
6S/1W-25D1	360	Irrigation	9/ 7/49	542	1020	0.08	16	7.02	3.81	2.07	6.16	1.22	5.17	0.10
6S/1W-34P1		Irrigation	7/14/49	232	481	0.10	21	3.23	1.42	1.25	4.02	0.44	1.08	0.10
6S/2W-7J1		Irrigation and domestic	7/18/49	716	1340	0.18	19	6.69	7.63	3.32	8.25	4.15	2.63	1.31
6S/2W-9L1			5/26/49	712	1258	0.00	11	7.64	6.59	1.81	7.27	1.77	6.64	0.11
6S/2W-12P1		Stock	5/26/49	567	1250	0.13	22	5.10	6.24	3.27	8.80	3.34	1.46	0.49
6S/2W-14M2	800	Municipal	5/26/49	120	1099	0.28	79	1.57	0.83	8.99	5.08	6.06	0.21	0.00
6S/2W-15D1	700	Irrigation	7/14/49	158	483	0.17	48	1.91	1.24	2.94	4.46	0.54	0.65	Tr
6S/2W-16H1	600	Irrigation	7/14/49	332	694	0.09	24	4.44	2.21	2.12	5.15	1.07	2.06	Tr
6S/2W-29D2		Irrigation	8/31/49	296	637	0.05	27	3.64	2.28	2.24	6.07	0.86	0.42	0.21
6S/3W-3L1	350	Municipal	8/29/49	229	662	0.27	42	3.01	1.57	3.25	4.34	1.93	1.25	0.04
6S/1E-30N1	316	Irrigation and domestic	5/23/49	664	1299	0.00	19	7.04	6.24	3.11	10.06	2.56	3.76	0.00
6S/1E-33H1		Irrigation	8/ 8/49	316	680	0.00	24	4.25	2.06	2.01	5.28	1.64	1.09	Tr
6S/1E-34Q1		Irrigation	5/24/49	1716	4120	0.25	33	19.24	15.08	17.13	9.14	22.50	19.43	Tr
7S/1W-3G1			9/20/49	233	483	0.11	19	3.11	1.55	1.09	3.79	0.47	1.30	0.09
7S/1W-18N1	525	Irrigation	9/12/49	234	516	0.21	28	2.86	1.81	1.77	3.99	0.94	0.62	0.11
7S/2W-12K1	510	Irrigation	9/20/49	257	565	0.17	24	2.77	2.37	1.62	4.81	1.10	0.44	0.14
7S/1E-15B1		Irrigation and domestic	5/27/49	374	735	0.00	17	3.41	4.06	1.52	6.33	0.70	1.79	0.07
7S/1E-25E4	268	Irrigation	5/27/49	303	610	0.00	19	1.44	4.62	1.42	5.63	0.70	0.93	0.06
Average				434	1181	0.17	31	4.65	4.02	3.85	6.25	3.10	2.63	.15
Forebay Zone														
5S/1E-32P1	250	Irrigation	5/24/49	193	1205	0.59	70	2.11	1.75	9.05	6.92	3.23	2.63	0.07
6S/1E-5G1	278	Irrigation	9/ 7/49	292	926	0.44	48	3.39	2.44	5.27	6.70	2.62	1.06	0.26
6S/1E-6A1		Irrigation and domestic	6/ 8/49	83	565	0.27	75	0.88	0.78	4.88	5.00	0.60	0.99	Tr
6S/1E-22B1		Irrigation	5/24/49	244	1012	1.88	62	2.64	2.24	7.81	6.65	2.63	3.33	Tr
6S/1E-22E2		Irrigation	6/22/49	173	733	1.01	61	2.43	1.03	5.35	5.81	1.36	1.54	0.10
7S/1E-32R1		Irrigation	7/16/49	233	454	0.15	15	2.04	2.62	0.84	4.23	0.32	0.53	0.10
8S/1W-3D1	818		9/22/49	198	488	0.05	30	2.14	1.83	1.66	3.46	1.19	0.60	Tr
8S/1E-8R1		Irrigation	8/ 8/49	199	373	0.17	15	1.88	2.10	0.70	3.43	0.32	0.57	0.03
8S/1E-10J2	183	Irrigation	8/ 8/49	366	758	0.16	24	3.37	3.96	2.29	5.73	1.89	1.63	0.07
8S/1E-26H1	25	Irrigation	8/ 8/49	278	498	0.16	14	1.35	4.21	0.91	4.70	0.70	0.71	0.04
8S/2E-7A3	203	Irrigation	8/ 8/49	238	451	0.11	19	2.11	2.66	1.09	4.24	0.41	0.90	0.04
8S/2E-34R1	150	Irrigation	8/ 8/49	256	680	0.12	21	2.73	2.39	1.36	4.58	0.53	0.90	0.13
9S/3E-7C1	170	Irrigation	8/ 8/49	242	474	0.16	19	2.62	2.21	1.11	3.91	0.45	1.18	0.11
Average				230	663	0.41	36	2.28	2.32	3.26	5.03	1.25	1.27	0.07
SOUTH SANTA CLARA VALLEY														
Pressure Zone														
10S/4E-28N2	322	Irrigation	8/ 3/49	193	431	0.09	28	2.06	1.80	1.53	3.75	0.53	0.57	0.09
11S/4E-4P2		Irrigation	7/27/49	236	476	0.10	18	2.28	2.45	1.05	4.38	0.42	0.44	0.24
11S/4E-10L1	220	Irrigation	7/27/49	434	820	0.16	17	3.88	4.80	1.72	6.94	1.02	1.84	0.13
11S/4E-11C1		Irrigation and domestic	7/27/49	260	608	0.10	27	2.62	2.59	1.94	5.92	0.87	0.15	0.09
11S/4E-13B1	673	Irrigation	7/27/49	110	788	0.42	77	1.41	0.80	7.30	5.45	2.25	1.15	Tr
11S/4E-14D1		Irrigation and stock	8/31/49	175	556	0.17	49	1.93	1.57	3.42	5.09	0.94	0.63	Tr
11S/4E-17A1	280	Irrigation	7/27/49	216	444	0.10	21	2.30	2.01	1.17	3.86	0.44	0.70	0.11
11S/4E-29G1	120	Irrigation	8/30/49	231	467	0.13	20	2.18	2.44	1.12	3.91	0.70	0.74	0.10
Average				232	573	0.16	32	2.33	2.31	2.41	4.91	0.89	0.78	0.10

TABLE 20—Continued

COMPLETE MINERAL ANALYSES OF GROUND WATERS IN SANTA CLARA VALLEY

Well number	Depth, in feet	Use	Date of sample	Hard- ness, ex- pressed in ppm of Ca CO ₃	Con- duct- ance, Ec × 10 ⁶ at 25° C.	Boron, in ppm	Per cent so- dium	Mineral constituents, in equivalents per million						
								Ca	Mg	Na	HCO ₃ + CO ₃	Cl	SO ₄	NO ₃
SOUTH SANTA CLARA VALLEY—Continued														
Forebay Zone														
9S/3E-22R2	240	Irrigation and domestic	7/29/49	457	1243	0.23	35	4.25	4.89	4.95	3.43	6.95	2.44	0.43
9S/3E-28B2			7/29/49	505	1390	0.27	34	4.32	5.78	5.20	3.99	9.41	1.40	0.10
9S/3E-35M1	225	Irrigation	8/31/49	182	354	0.09	17	1.55	2.09	0.74	3.01	0.40	0.36	0.24
10S/3E-4A2			7/29/49	1142	2470	0.17	15	11.30	11.53	4.06	4.60	19.62	2.10	0.10
10S/3E-25K1	141	Irrigation	8/30/49	210	412	0.04	20	1.84	2.37	1.03	3.70	0.58	0.30	0.23
10S/3E-34L1		Irrigation and domestic	9/20/49	188	368	0.09	18	1.95	1.82	0.85	3.17	0.32	0.79	Tr
10S/3E-35J1	289		9/20/49	455	909	0.00	21	7.59	1.51	2.41	7.52	1.95	1.60	Tr
10S/4E-27B1	412	Irrigation	8/ 3/49	220	690	0.14	48	2.36	2.05	3.98	6.74	0.94	0.57	Tr
Average				420	980	0.13	26	4.40	4.01	2.90	4.52	5.02	1.20	0.14

Francisco Bay has undoubtedly been reduced below sea level. The salt water of the bay thus has a higher head than the fresh water in the pressure aquifers in such places, and is entering the pressure aquifers at their points of free contact with sea water. Dredging taking place on the floor of San Francisco Bay in recent years has tended to further remove capping beds, and may have exposed the aquifers to an extent as yet unknown. Thus, if draft on ground water in the pressure zone of North Santa Clara Valley continues as at present, salt water can be expected to move into the pressure aquifers beneath San Francisco Bay and from thence into the pressure zone. Indeed, intrusion of sea water from San Francisco Bay into aquifers in the Niles Cone area of Alameda County has already occurred, and degradation of quality of the ground water in adjacent areas by spreading of the poor quality water is now occurring.

Studies made by Tolman and Poland in 1940 showed the existence of a fringe of pollution from saline water near San Francisco Bay. These investigations indicated that the pollution was caused chiefly by movement of saline perched ground water through defective and abandoned wells, and through gravel deposits of active streams discharging into the bay.

In 1940, pollution of ground water in the tideland area was primarily restricted to gravels within 100

feet of the ground surface. Relatively impervious layers of blue clay prevented percolation of the polluted water below this depth, except in areas where the clay layers had been punctured. Many wells formerly piercing the blue clay in the tideland area near Palo Alto and in the vicinity of Alviso have been plugged to prevent percolation of salt water to the principal pumping zone.

Waters in 27 of the wells used in 1940 by Tolman and Poland to locate the fringe of pollution were re-sampled in 1949 and tested for chloride content. Comparison of the recent and antecedent analyses showed no appreciable change in chloride concentration at these wells during the nine years. This indicated that pollution of deeper pressure aquifers by perched ground water had not generally increased, with the exception of possible pollution of ground water in the Palo Alto area.

Mineral analyses of water samples representative of ground waters in the Santa Clara Valley are presented in Table 20. Results of determination of total hardness in water samples collected from ground water in the Santa Clara Valley are also presented in Table 20. Partial mineral analyses of water samples collected from wells in the Santa Clara Valley are presented in Appendix G.

CHAPTER III

WATER UTILIZATION AND SUPPLEMENTAL REQUIREMENTS

The nature and extent of water utilization and of requirements for supplemental water in the Santa Clara Valley, both at the present time and under probable conditions of ultimate development, are considered in this chapter. In connection with the discussion, the following terms are used as defined:

Water Utilization—This term is used in a broad sense to include all employments of water by nature or man, whether consumptive or nonconsumptive, as well as irrecoverable losses of water incidental to such employment, and is synonymous with the term "water use."

Factors of Water Demand—Those factors pertaining to specific rates, times, and places of delivery of water, losses of water, quality of water, etc., imposed by the control, development, and use of water for beneficial purposes.

Water Requirement—The amount of water needed to provide for all beneficial uses of water and for irrecoverable losses incidental to such uses. As used in this bulletin, the term refers to consumptive use of water in forebay zones plus pumpage in pressure zones.

Supplemental Water Requirement—The water requirement over and above the sum of safe ground water yield and safe surface water yield.

Consumptive Use of Water—This refers to water consumed by vegetative growth in transpiration and building of plant tissue, and to water evaporated from adjacent soil, from water surfaces, and from foliage. It also refers to water similarly consumed and evaporated by urban and nonvegetative types of land use.

Applied Water—The water delivered to a farmer's headgate in the case of irrigation use, or to an individual's meter in the case of urban use, or its equivalent. It does not include direct precipitation.

Ultimate—This refers to conditions after an unspecified but long period of years in the future when land use and water supply development will be at a maximum and essentially stabilized. It is realized that any present forecasts of the nature and extent of such ultimate development, and resultant water utilization, are inherently subject to possible large errors in detail and appreciable error in the aggregate. However, such forecasts, when based upon best available data and present judgment, are of

value in establishing long-range objectives for development of water resources. They are so used herein, with full knowledge that their re-evaluation after the experience of a period of years may result in considerable revision.

The present water requirement in the Santa Clara Valley was determined from both records and estimates. Estimates of consumptive use of water were made by the application of appropriate unit use factors to actual or estimated land use patterns. Estimates of applied water were made from records of pumping applications to selected plots of principal irrigated crops, and from records of delivery of water obtained in connection with this and other investigations.

The probable ultimate water requirement was estimated by multiplying acreages of the estimated ultimate land use pattern by appropriate mean unit values of water requirement. Supplemental requirements for water were estimated as the differences between derived values of safe yield and requirement under both present and ultimate conditions of development.

Water utilization is considered and evaluated in this chapter under the general headings, "Present Water Supply Development," "Land Use," "Unit Use of Water," "Past and Present Water Requirements," "Probable Ultimate Water Requirement," "Nonconsumptive Water Requirements," and "Factors of Water Demand." Supplemental water requirements are similarly treated under the two general headings, "Present Supplemental Requirement" and "Probable Ultimate Supplemental Requirement."

WATER UTILIZATION

The Santa Clara Valley has long been one of the most important agricultural areas in the State. Early agricultural efforts were limited to the growing of grains and other dry-farmed crops. Although extensive plantings of orchards were made during the 19th century, for many years these were not generally irrigated. A series of dry years in the latter part of that century resulted in damage to many of the valley orchards, and indicated the necessity for providing a firm irrigation water supply to supplement the variable annual precipitation. The increased yields and improved quality of fruit produced from irrigated orchards offered further stimulus to the trend toward more irrigation.

Inasmuch as the Santa Clara Valley streams are intermittent, having little or no flow during the summer season, irrigators found it more expedient to utilize water available in underground storage than to provide for artificial retention of tributary runoff in surface storage reservoirs. Utilization of ground water increased rapidly after the turn of the century to meet not only irrigation requirements, but also the ever increasing municipal and industrial water needs of metropolitan San Jose and suburban communities.

Of the total amount of water presently utilized in Santa Clara Valley, approximately 73 per cent is consumed in the production of irrigated crops, while the remainder is consumed by dry-farmed crops and native vegetation, urban areas, farmsteads, and miscellaneous types of land use. It is considered probable that the predominant importance of irrigated agriculture, as related to utilization of water, will continue to prevail in South Santa Clara Valley, while in North Santa Clara Valley the future development will largely be urban.

Present Water Supply Development

Approximately 96 per cent of all water requirements in the Santa Clara Valley are presently met by water pumped from underlying ground water basins. Irrigated lands utilizing ground water are generally served by individually owned and operated pumps. It has been estimated that in 1948 there were about 3,700 irrigation wells in the valley. Water supplied in the Santa Clara Valley for other than agricultural uses is furnished by municipal systems, water districts, and private and mutual companies.

Public utilities serving water in the Santa Clara Valley for domestic and industrial use, together with

TABLE 21
GROUND WATER PUMPAGE BY PUBLIC UTILITIES FURNISHING DOMESTIC AND INDUSTRIAL WATER IN SANTA CLARA VALLEY

Organization	Area served	Ground water pumpage, in acre-feet	
		1948	1953
Agnew Water Works.....	Agnew.....	30	30
California Water Service Co.....	Los Altos.....	770	1,190
Campbell Water Co.....	Campbell.....	700	1,020
San Jose Water Works ^a	Campbell.....	12,600	15,500
	Cupertino.....		
	Saratoga.....		
	Los Gatos.....		
	San Jose.....		
San Martin Water Works.....	San Martin.....	30	30
Suburban Water Co. of Loyola.....	Cupertino.....	1,490	3,420
Water Works of Monte Vista, Ltd.....	Monte Vista.....	190	390
Total.....		15,810	21,580

^a Also diverted 5,040 acre-feet of water in 1948 and 12,500 acre-feet in 1953, from Los Gatos and Saratoga Creeks.

^b Estimated.

^c Owned by California Water Service Company.

the total ground water pumpage by each in 1948 and 1953, are listed in Table 21.

Cities and communities within Santa Clara County having publicly owned water systems, and their pumpage of ground water in 1948 and 1953, are shown in Table 22.

TABLE 22
GROUND WATER PUMPAGE BY PUBLICLY OWNED SYSTEMS IN SANTA CLARA VALLEY

City or community	Ground water pumpage, in acre-feet	
	1948	1953
Gilroy ^a	470	1,030
Morgan Hill.....	220	260
Mountain View.....	1,040	1,910
Palo Alto ^b	750	4,250
Santa Clara.....	2,130	2,890
Suburban service.....	930	1,000
Sunnyvale.....	1,450	2,120
TOTAL.....	6,990	13,460

^a Also diverted 120 acre-feet of water from Uvas Creek in 1948.

^b Also obtained 3,600 acre-feet of water in 1948, and 2,740 acre-feet in 1953, from Hetch Hetchy Aqueduct.

^c Estimated.

In addition to the public utilities and privately owned systems, there are several smaller communities, and numerous commercial and industrial enterprises, which pump from private wells. The total draft on ground water by these users was estimated to be approximately 9,000 acre-feet in 1948, and 13,000 acre-feet in 1953. In Table 23 are listed water districts and mutual water companies that provide service in the Santa Clara Valley. Pumpage of ground water by these companies and districts is included in the foregoing estimates of 9,000 acre-feet and 13,000 acre-feet for 1948 and 1953, respectively.

TABLE 23
AREAS SERVED BY WATER DISTRICTS AND MUTUAL WATER COMPANIES IN SANTA CLARA VALLEY

District or company	Area served
Los Robles Mutual Water Company.....	Palo Alto
Redwood Mutual Water Company.....	Los Gatos
Stanford Water Company.....	Palo Alto and Stanford University

The total draft on ground water by all the foregoing water service agencies was approximately 31,800 acre-feet in 1947-48, and 48,000 acre-feet in 1952-53. It was estimated that farmstead draft in both 1947-48 and 1952-53 was approximately 2,300 acre-feet. The estimated total nonagricultural pumping draft on ground water in the Santa Clara Valley was, therefore, 34,100 acre-feet in 1947-48, and 50,300 acre-feet in 1952-53.

The area of lands in the Santa Clara Valley served by water diverted from surface streams was once appreciable but is now insignificant. It has been

reported that the maximum use of surface diverted waters occurred between 1904 and 1906, when approximately 13,000 acres were irrigated in this manner. In 1921 the area so irrigated amounted to less than 3,000 acres. At present there are a few diversions from Los Gatos Creek. However, subdivisions and highway construction have made service of these surface waters increasingly difficult.

With the foregoing minor exceptions, irrigation water service in the Santa Clara Valley is from ground water. Lands which were under irrigation in 1947-48 in water service areas of North and South Santa Clara Valleys are indicated in Table 24.

TABLE 24
IRRIGATED LANDS IN NORTH AND SOUTH
SANTA CLARA VALLEYS, 1947-48

Division	Acreage
North Santa Clara Valley	
Forebay Zone.....	58,500
Pressure Zone.....	41,900
Subtotal.....	100,400
South Santa Clara Valley	
Forebay Zone.....	15,400
Pressure Zone.....	14,300
Subtotal.....	29,700
TOTAL.....	130,100

Water conservation works in North Santa Clara Valley retain a portion of the winter runoff that would otherwise waste to San Francisco Bay. Waters stored in surface reservoirs, constructed and maintained by the Santa Clara Valley Water Conservation District, are released and percolated in stream channels for storage underground. Conservation works constructed and maintained by the San Jose Water Works store waters for municipal use. In addition, numerous small conservation dams have been built by the Soil Conservation Service of the United States Department of Agriculture. Location of the major existing conservation works, described hereinafter, are shown on Plate 17, entitled "Existing Water Conservation Works and Works Considered for Future Development, 1955."

Major conservation works constructed and maintained by the Santa Clara Valley Water Conservation District and pertinent data relating thereto, are presented in the following tabulation:

Dam	Location	Stream bed elevation, in feet	Reservoir storage capacity, in acre-feet
Coyote	Coyote Creek	1,640	25,000
Anderson	Coyote Creek	405	75,000
Calero	Arroyo Calero	396	9,200
Almaden	Alamitos Creek	505	2,000
Guadalupe	Guadalupe Creek	481	3,500
Lexington	Los Gatos Creek	460	25,000
Stevens Creek	Stevens Creek	425	4,000

Percolation works have been constructed by the Santa Clara Valley Water Conservation District on all but one of the major streams. The Penitencia Creek percolation ponds, constructed along an abandoned railroad right of way and paralleling Penitencia Creek, consists of a line of ponds totaling 8,000 feet in length and having a total area of 4.1 acres. The percolation capacity of these ponds is a rate of about 15 second-feet. The Coyote Creek percolating pond is located in the stream bed of Coyote Creek, just below the Lower Gorge and about one mile north of Coyote Station. It is formed by an 8-foot-high removable flashboard dam with reinforced-concrete floor and abutments. The area of the pond is 32 acres, and its average capacity for percolation in 1947 was a rate of about 20 second-feet.

The Alamitos Creek percolation ponds are located at the junction of Alamitos and Guadalupe Creeks, and are formed by long low wire-enclosed gravel "sausages" across the stream beds. A 6-foot-high removable flashboard dam, with reinforced-concrete abutments and stilling basin, is located at the downstream end of the percolation area. The percolation area totals about 17 acres.

Percolation works on Los Gatos Creek are limited to small diversions for off-stream percolation and flooding of highly porous gravel areas. Vasona Dam on Los Gatos Creek is located about 2 miles below Los Gatos. The dam is constructed of two rolled-earth embankments, each 30 feet in height, and with a centrally placed reinforced-concrete spillway 210 feet in width. Storage capacity of Vasona Reservoir is 412 acre-feet, and the reservoir covers an area of about 59 acres. Water from the reservoir is diverted to the unlined Vasona Canal, which has a capacity of 75 second-feet. The canal generally runs through porous ground for about 2.6 miles to San Tomas Aquinas Creek, where the diverted water is spread for percolation upon adjacent orchard land, and in San Tomas Aquinas Creek when percolation capacity above the natural flow in that creek allows. The Vasona Canal Extension, comprising a pumping plant and pipe line, has a capacity of 15 second-feet. Water is conveyed in it a distance of 1.65 miles from the Vasona Canal to Saratoga Creek for percolation in that creek. The Upper Page Ditch diverts water from Los Gatos Creek, about 1.5 miles below Vasona Dam. The diversion is made by means of a low concrete and flashboard dam, and the diverted water is conveyed a distance of 1.8 miles to San Tomas Aquinas Creek. Percolation of the diverted water is accomplished by spreading the water on orchard land, and by making use of the percolating capacity of San Tomas Aquinas Creek. The ditch also supplies water to three percolating ponds having a total area of 3.3 acres. Lower Page Dam, located about 1.5 miles below the Upper Page Dam on Los Gatos Creek, is a reinforced-concrete diversion dam with low removable flashboards. The dam ponds water back over a very porous section



Courtesy San Jose Chamber of Commerce

Calero Dam and Reservoir on Arroyo Calero

of the stream bed of Los Gatos Creek for about one-half mile. Water is diverted at the dam to the Lower Page Ditch, for irrigation and percolation on orchard land in the vicinity of Campbell.

In addition to the foregoing works, the Santa Clara Valley Water Conservation District has constructed a number of conduits to convey waters from areas of surplus to areas of deficiency. The Coyote Canal, about 8.9 miles in length, has a capacity of 100 second-feet. The canal conveys water conserved in Coyote and Anderson Reservoirs to the Coyote Canal Extension, to Coyote Creek, and to the Coyote percolation pond. The Coyote Canal Extension has a total length of about 9 miles. It has a capacity of 65 second-feet to Metcalf Road, where water at the rate of 50 second-feet is diverted into the recently constructed Coyote-Alamitos Canal. The remaining 15 second-feet is pumped into the Evergreen Canal. The Coyote-Alamitos Canal has a capacity of 50 second-feet and conveys water a distance of about 9 miles to the Alamitos percolation pond. The Evergreen Canal has a capacity of 15 second-feet, and comprises about 2,500 feet of pipe line and about 7 miles of canal. Water in the canal is conveyed to Dry Creek.

Waters conserved in Almaden Reservoir are conveyed in the Almaden-Calero Canal, having a capacity of 100 second-feet, a distance of about 4.5 miles to Calero Reservoir. The conserved waters of Almaden and Calero Reservoirs are percolated in the Alamitos Creek stream bed and the Alamitos percolation pond. Waters conserved in Guadalupe Reservoir are released for percolation in the Guadalupe Canal stream bed and the Alamitos percolation pond.

Lexington Reservoir conserves the winter flows of Los Gatos Creek, which are released for percolation during periods of low runoff. Waters released from Lexington Reservoir are diverted from Los Gatos Creek through the Upper Page Canal and the Vasona Canal to percolation ponds on San Tomas Aquinas Creek and Saratoga Creek. Waters conserved in Stevens Creek Reservoir are released for percolation in the stream bed of Stevens Creek.

Conservation works of the San Jose Water Works include Lake Elsmann, formerly known as Austrian Reservoir, and Williams Dam and Reservoir, both on Los Gatos Creek; Lake Ranch Dam and Reservoir on Beardsley Creek; and Upper Howell Dam and Reservoir and Lower Howell Dam and Reservoir, both on Rundell Creek. Pertinent data pertaining to these works are presented in the following tabulation:

Dam	Location	Stream bed elevation, in feet	Reservoir storage capacity, in acre-feet
Lake Elsmann	Los Gatos Creek	940	6,140
Williams	Los Gatos Creek	1,152	160
Lake Ranch	Beardsley Creek	1,771	323
Upper Howell	Rundell Creek	1,376	243
Lower Howell	Rundell Creek	1,349	153

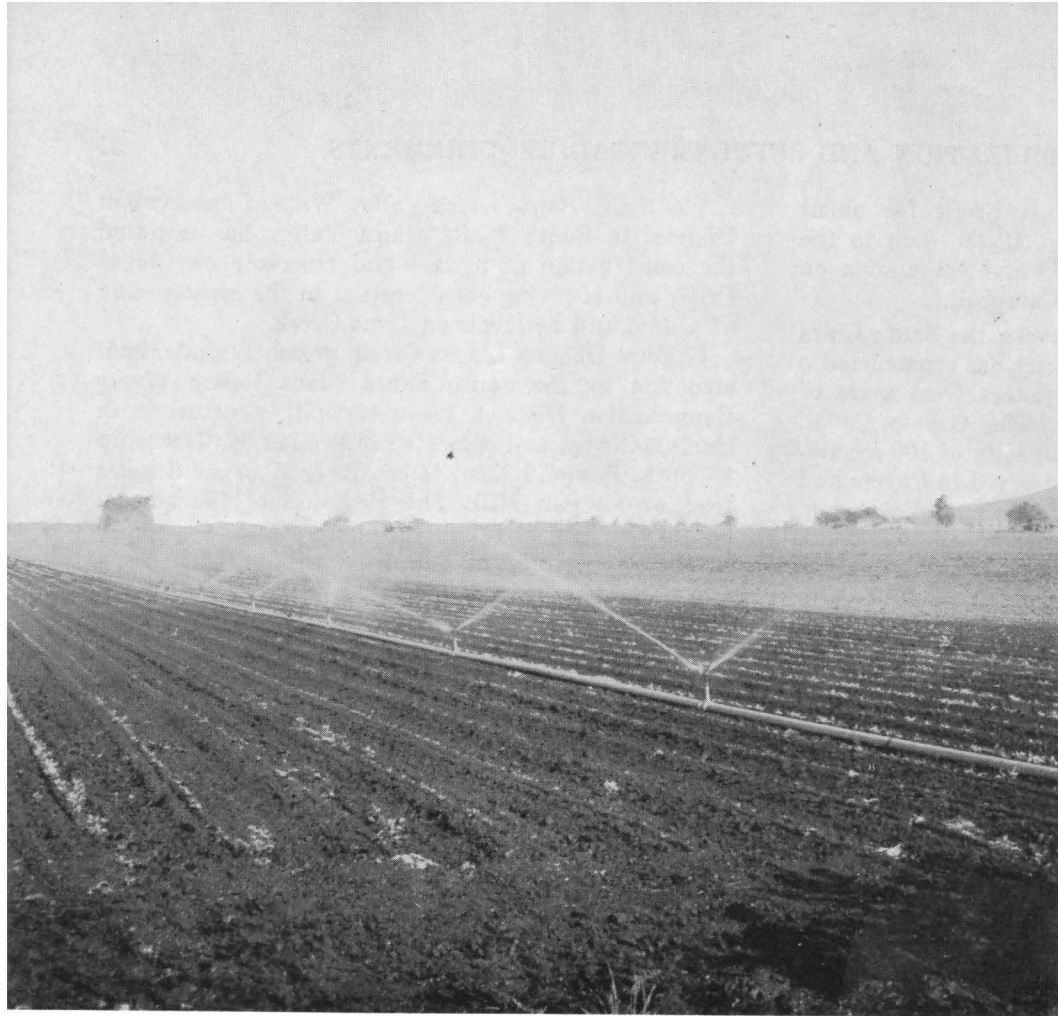
The South Santa Clara Valley Water Conservation District in South Santa Clara Valley has initiated the construction of a dam and reservoir on Llagas Creek and is giving consideration to the construction of a dam and reservoir on Uvas Creek.

Chesbro Dam on Llagas Creek, presently under construction by the South Santa Clara Valley Water Conservation District, is an earthfill structure with chute spillway, and is located in Section 30, Township 9 South, Range 3 East, M. D. B. & M., some 3 miles west of Morgan Hill. The elevation of the stream bed at the dam is 441 feet, and the storage capacity of the reservoir when completed will be 7,500 acre-feet. The dam when completed will be 87 feet in height from stream bed to spillway lip, and will have a crest elevation of 543 feet. The dam will have a crest length of about 700 feet, a crest width of 30 feet, and 3:1 upstream and downstream slopes.

Appropriation of Water. Since the effective date of the Water Commission Act on December 19, 1914, applications to appropriate water of streams in the Santa Clara Valley have been filed with the Division of Water Resources or its predecessors. As of December 31, 1954, 81 applications to appropriate water of streams of the Santa Clara Valley were on file with the Division of Water Resources. These applications are listed in Appendix H, together with pertinent information on the proposed diversions and uses of water, and the present status of the applications.

The applications listed in Appendix H should not be construed as comprising a complete or even partial statement of water rights in the Santa Clara Valley. They do not include appropriative rights initiated prior to December 19, 1914, riparian rights, correlative rights of overlying owners in ground water basins, nor prescriptive rights which may have been established on either surface streams or ground water basins, none of which are of record with the Division of Water Resources. In general, water rights may be firmly established only by court decree.

Dams Under State Supervision. The Department of Public Works, acting through the agency of the State Engineer, supervises the construction, enlargement, alteration, repair, maintenance, operation, and removal of dams, for the protection of life and property within California. All dams in the State excepting those under federal jurisdiction, are under the jurisdiction of the Department. "Dam" means any artificial barrier, together with appurtenant works, if any, across a stream, watercourse, or natural drainage area, which does or may impound or divert water, and which either (a) is or will be 25 feet or more in height from natural stream bed to crest of spillway, or (b) has or will have an impounding capacity of 50 acre-feet or more. Any such barrier, which is or will be not in excess of six feet in height, regardless of storage capacity, or which has or will have a storage



*Sprinkler Irrigation in
Santa Clara Valley*



*Orchards in Bloom,
Santa Clara Valley*

*Courtesy San Jose
Chamber of Commerce*

capacity not in excess of 15 acre-feet regardless of height, is not considered a dam. Approximately 26 dams in and adjacent to the Santa Clara Valley are presently under State supervision. Pertinent data relating to these dams are included in Appendix I.

Land Use

As a first step in estimating the water requirements in the Santa Clara Valley, determinations were made of the nature and extent of land use during the base periods and during the investigational seasons. Similarly, the probable nature and extent of ultimate land use as related to water requirement was estimated.

Past and Present Patterns of Land Use. The United States Bureau of the Census has reported that the irrigated area in Santa Clara County increased from 70,132 acres in 1919 to 96,130 acres in 1929, decreased to 95,959 acres in 1939, and increased to 101,172 acres in 1949.

A detailed land use survey of agricultural lands, and a general delimitation of urban areas in the Santa Clara Valley, were made during 1947-48, 1948-49, and 1954-55 in connection with the current investigation. Agricultural developments were mapped, showing the location and distribution of cropped lands.

In 1948-49, urban areas of North Santa Clara Valley were mapped in connection with the current State-wide Water Resources Investigation, supplementing the aforementioned survey. Developments were grouped into single-family, residential, multiple dwelling, commercial, industrial, irrigated park, institutional, and other miscellaneous classifications. For purposes of this bulletin, the land use pattern existing during the 1948-49 season was considered to represent "present" conditions of development in the area, and is so referred to in subsequent discussion.

Plate 16, entitled "Land Use, 1955," depicts areas of irrigated land, urban developments, and nonirrigated land, determined from the foregoing surveys. A tabulation, listing class and type of land use in North and South Santa Clara Valleys during 1948-49, is presented in Table 25.

Estimates of average land use patterns prevailing in North and South Santa Clara Valleys during the respective base periods were based on the land use surveys of 1947-48 and 1948-49, records of electrical energy consumption, and records of water deliveries. Average areas of irrigated lands during these periods were estimated from the 1947-48 land use data, by application of ratios based on records of agricultural electric energy consumption, adjusted for ground water level fluctuations and variations in available precipitation. The average base period urban areas in North Santa Clara Valley were estimated from the 1949 data, using records of water deliveries

TABLE 25
PATTERN OF LAND USE IN NORTH AND SOUTH
SANTA CLARA VALLEYS, 1948-49
(In acres)

Class and type of land use	North Santa Clara Valley			South Santa Clara Valley		
	Fore-bay Zone	Pressure Zone	Total	Fore-bay Zone	Pressure Zone	Total
Irrigated Lands						
Alfalfa.....	500	2,000	2,500	100	1,000	1,100
Permanent pasture.....	1,100	1,700	2,800	900	700	1,600
Deciduous orchard.....	48,700	23,200	71,900	11,200	6,300	17,500
Beans.....	200	1,000	1,200	200	500	700
Tomatoes.....	300	300	600	200	900	1,100
Truck.....	3,600	12,700	16,300	600	3,100	3,700
Sugar beets.....	2,000	1,000	3,000	200	1,500	1,700
Vineyards.....	2,100	0	2,100	2,000	300	2,300
Subtotals.....	58,500	41,900	100,400	15,400	14,300	29,700
Nonirrigated Lands						
Dry-farmed and native grasses.....	11,900	11,400	23,300	6,300	2,800	9,100
Dry-farmed orchard.....	1,000	---	1,000	400	---	400
Fallow lands.....	200	400	600	400	400	800
Brush and trees.....	2,700	1,500	4,200	600	500	1,100
Interior hills.....	---	---	---	5,200	---	5,200
Subtotals.....	15,800	13,300	29,100	12,900	3,700	16,600
Urban Areas						
Residential.....	3,200	6,400	9,600	---	---	---
Multi-residential.....	100	200	300	---	---	---
Commercial.....	100	600	700	---	---	---
Industrial.....	100	1,200	1,300	---	---	---
Irrigated parks.....	300	300	600	---	---	---
Airfields.....	100	100	200	---	---	---
Institutions.....	300	300	600	---	---	---
Military.....	---	1,200	1,200	---	---	---
Streets and sidewalks.....	1,700	4,700	6,400	---	---	---
Vacant lots.....	500	2,500	3,000	---	---	---
Subtotals.....	6,400	17,500	23,900	*800	*300	*1,100
Farmsteads and Miscellaneous						
Farmsteads.....	700	1,200	1,900	300	300	600
Roads and railroads.....	4,700	3,300	8,000	2,400	1,800	4,200
Water surface.....	400	1,400	1,800	---	---	---
Subtotals.....	5,800	5,900	11,700	2,700	2,100	4,800
TOTALS.....	86,500	78,600	165,100	31,800	20,400	52,200

* Breakdown of subtotals not available.

by the San Jose Water Works and other entities as indices. It was assumed that the area of farmsteads varied in proportion to irrigated agricultural development, while the areas of miscellaneous land classifications remained equal to the 1948 values.

A summary of the estimated average patterns of land use prevailing during the 13-year and 16-year base periods for North and South Santa Clara Valleys, respectively, is given in Table 26.

Probable Ultimate Land Use. Several assumptions were made as to the probable distribution of ultimate urban and agricultural developments in North Santa Clara Valley, and in portions of the contiguous

hills and marshlands considered habitable. Based on present tendencies, it was assumed that all land susceptible of development in the forebay zone of the northern valley, and on adjacent habitable hills, will ultimately be used for urban purposes. However, it seems likely that a small portion of the pressure zone in North Santa Clara Valley will remain in agricultural use, and a figure of 10 per cent was arbitrarily taken as the proportion of that area which will ultimately be occupied by that class.

To compute the net valley floor acreages used in evaluating the amounts of urban and agricultural development, present wastelands and the estimated ultimate rural road areas were deducted from the gross investigational area. Outside the northern valley are about 53,700 acres of foothill and salt marshlands considered susceptible of urban development. Of this acreage, about 9,300 acres of salt marshes adjacent to San Francisco Bay are now used for evaporating sea water for salt production, or are owned by the salt companies for this purpose for future development. Thus, the assumed net habitable portion of the hills and marshlands adjacent to the investigational area is about 44,400 acres, of which about 4,000 acres are marshlands, and about 40,400 acres are hills. It was further assumed that under ultimate conditions of development the hill lands will have about one-half the density of valley floor development, but will be of similar pattern.

The present land use pattern in urban areas of the San Francisco Bay Area, estimated in connection with studies being made by the Division of Water Resources, for the State-wide Water Resources Investigation, was used as a guide in estimating the pattern and proportions of the probable ultimate urban area in North Santa Clara Valley. It was assumed that the probable ultimate industrial area will be largely located in the pressure zone.

The estimated pattern and proportions of land use within the probable ultimate urban area of North Santa Clara Valley is presented in Table 27.

TABLE 26

**SUMMARY OF AVERAGE PATTERN OF LAND USE
DURING BASE PERIODS IN NORTH AND
SOUTH SANTA CLARA VALLEYS**

(In acres)

Class of land use	North Santa Clara Valley			South Santa Clara Valley		
	Forebay Zone	Pressure Zone	Total	Forebay Zone	Pressure Zone	Total
Irrigated lands.....	53,300	39,000	92,300	13,800	12,900	26,700
Nonirrigated lands.....	23,300	23,500	46,800	14,700	5,200	19,900
Urban areas.....	4,200	10,400	14,600	600	200	800
Farmsteads.....	600	1,100	1,700	300	300	600
Miscellaneous.....	5,100	4,600	9,700	2,400	1,800	4,200
TOTALS.....	86,500	78,600	165,100	31,800	20,400	52,200

TABLE 27

**PATTERN OF URBAN LAND USE IN NORTH SANTA CLARA
VALLEY UNDER PROBABLE ULTIMATE DEVELOPMENT**

(In percent)

Type of land use	Total	Forebay Zone	Pressure Zone
Single-family residential.....	41.8	44.8	38.1
Multiple-family residential.....	3.3	3.6	3.0
Commercial.....	4.1	4.4	3.7
Industrial.....	8.1	3.7	13.5
Irrigated parks.....	7.0	7.6	6.3
Institutions.....	3.2	3.4	2.8
Airfields.....	2.5	2.7	2.2
Streets and sidewalks.....	30.0	29.8	30.4
Vacant.....	0.0	0.0	0.0
TOTALS.....	100.0	100.0	100.0

The percentages indicated for industrial development in Table 27 are greater than the present ratio of industrial to total urban land use, which presently amounts to about one per cent. The assumed increase was based on the consideration that when agriculture ceases to be of major importance, industry will assume the dominant role in the economy of North Santa Clara Valley.

Lands in South Santa Clara Valley regarded as irrigable are indicated on Plate 16. It was assumed that 95 per cent of the gross irrigable area will be irrigated in any one year. It was further assumed that the present proportionate distribution of land use will prevail for new lands brought under irrigation in South Santa Clara Valley. For urban areas, ultimate land use was considered to be about 35 per cent greater than that under present conditions.

The patterns of land use estimated for probable ultimate development in North and South Santa Clara Valleys are indicated in Table 28.

TABLE 28

**ESTIMATED PROBABLE ULTIMATE PATTERN OF LAND USE
IN NORTH AND SOUTH SANTA CLARA VALLEYS**

(In acres)

Class and type of land use	North Santa Clara Valley			South Santa Clara Valley		
	Forebay Zone	Pressure Zone	Total	Forebay Zone	Pressure Zone	Total
Irrigated lands.....	0	7,300	7,300	22,000	17,300	39,300
Nonirrigated lands.....	0	0	0	0	0	0
Urban areas.....	83,400	67,600	151,000	1,200	300	1,500
Farmsteads.....	0	200	200	400	400	800
Miscellaneous.....	3,100	3,500	6,600	8,200	2,400	10,600
Subtotals.....	86,500	78,600	165,100	31,800	20,400	52,200
Hills.....	40,400	0	40,400	-----	-----	-----
Marshlands.....	0	4,000	4,000	-----	-----	-----
Subtotals.....	40,400	4,000	44,400	-----	-----	-----
TOTALS.....	126,900	82,600	209,500	31,800	20,400	52,200

Unit Use of Water

The second step in evaluation of water requirements of the Santa Clara Valley involved the determination of unit values of consumptive use of water for the forebay zones, and unit values of applied water for the pressure zones, for each of the several types of water-consuming land use.

Estimates of unit values of consumptive use of water were largely based on the results of prior investigations and studies in other areas. A procedure suggested by Harry F. Blaney and Wayne D. Criddle of the Soil Conservation Service, United States Department of Agriculture, in their reports entitled "A Method of Estimating Water Requirements in Irrigated Areas From Climatological Data," dated December, 1947, and "Determining Water Requirements in Irrigated Areas From Climatological and Irrigation Data," dated August, 1950, was generally utilized for adjustment of available data on unit consumptive use by irrigated crops in other localities to correspond with conditions existing in the Santa Clara Valley. This method involves correlation of the data on the basis of variations in average monthly temperatures, monthly percentages of annual daytime hours, precipitation, and lengths of growing season. It disregards certain generally unmeasured factors, such as wind movement, humidity, etc. Average monthly temperatures at San Jose and Hollister were used for North and South Santa Clara Valleys, respectively, since these were considered representative of the two areas. Monthly percentages of annual daytime hours were determined for latitude $37^{\circ} 15' N.$, which passes approximately through the center of the area of investigation.

The following is an outline of the procedure utilized for estimating unit values of consumptive use of water:

1. The unit value for each irrigated crop during its growing season was taken as the product of available heat and an appropriate coefficient of consumption, where: (a) the available heat was the sum of the products of average monthly temperature and monthly per cent of daytime hours, and (b) the coefficient of consumption was one which has been selected as appropriate for California by Harry F. Blaney. Certain exceptions involved the use of modified coefficients, and coefficients estimated from consumptive use data available from other sources.

2. The unit value for each irrigated crop during its nongrowing season was taken as the amount of precipitation available, but not exceeding one to two inches of depth per month, depending on the type of crop.

3. The seasonal unit value for each irrigated crop was taken as the summation of values determined under items 1 and 2 for that crop.

4. Unit seasonal values for native annual grasses were taken as the summation of available precipitation up to but not exceeding two inches in depth per month.

5. Unit seasonal values for free water surfaces were estimated from short-period evaporation records at Alviso and along Coyote Creek. Unit seasonal consumptive use of water by roads and railroads was estimated from evaporation data and from amount of precipitation estimated to be retained on such type of land use.

6. Unit seasonal values for native vegetation other than annual grasses were estimated on the basis of available data for corresponding consumptive use of water in similar localities, due consideration being given to density and type of vegetation and depth to ground water.

7. The average unit seasonal value for farmsteads was estimated at 2.0 feet of depth, the estimate being based on data obtained in other similar localities.

8. Unit seasonal consumptive use of water values for urban area classifications were estimated from data obtained from the land use surveys made in connection with the current State-wide Water Resources Investigation.

Estimated mean unit seasonal values of consumptive use of water in the forebay zones of North and South Santa Clara Valleys, including values for consumption of both applied water and precipitation, are presented in Table 29. Weighted unit values of seasonal consumptive use of water for the different classes of land use, where pertinent, are also presented in Table 29. The weighted unit values were determined by dividing the summation of unit values of consumptive use of each type of land use, multiplied by their respective acreages, by the summation of acreage.

Although consumptive use of water is an appropriate measure of water requirement in the forebay zones of the Santa Clara Valley, it is not a correct measure of water requirement in the pressure zones. Since the unconsumed portion of applied water in the pressure zones is prevented from returning to the underlying aquifers for re-use, because of the relatively impermeable clay strata overlying the aquifers, determinations of water requirement in these zones were based on recorded and estimated applied water.

The term "applied water," as used in this bulletin, refers to that water other than precipitation which is delivered to a farmer's headgate in the case of irrigation use, or to an individual's meter in the case of urban use, or its equivalent. During two seasons of the investigation measurements were made of the amount of irrigation water applied to selected plots of principal crops grown in the Santa Clara Valley.

TABLE 29

ESTIMATED UNIT VALUES OF MEAN SEASONAL CONSUMPTIVE USE OF WATER IN FOREBAY ZONES OF NORTH AND SOUTH SANTA CLARA VALLEYS

(In feet of depth)

Class and type of land use	North Santa Clara Valley			South Santa Clara Valley		
	Applied water	Precipitation	Total	Applied water	Precipitation	Total
Irrigated lands						
Alfalfa.....	2.1	1.5	3.6	2.1	1.5	3.6
Permanent pasture.....	2.2	1.2	3.4	2.2	1.2	3.4
Deciduous orchard.....	1.2	1.3	2.5	1.2	1.3	2.5
Beans.....	0.7	1.1	1.8	0.8	1.0	1.8
Tomatoes.....	0.9	1.2	2.1	0.9	1.2	2.1
Truck.....	1.2	1.1	2.3	1.3	1.0	2.3
Sugar beets.....	1.2	1.1	2.3	1.3	1.0	2.3
Vineyards.....	0.9	1.2	2.1	1.0	1.1	2.1
Weighted average.....	1.2	1.3	2.5	1.2	1.3	2.5
Nonirrigated lands						
Dry-farmed and native grasses.....			1.4			1.4
Dry-farmed orchard.....			1.2			1.1
Brush and trees.....			3.0			3.0
Fallow lands.....			0.8			0.8
Interior hills.....			---			1.3
Weighted average.....			1.6			1.4
Urban areas						
Residential.....	2.0	---	2.0			
Multi-residential.....	6.0	---	6.0			
Commercial.....	4.0	---	4.0			
Industrial.....	8.0	---	8.0			
Irrigated parks.....	1.0	1.4	2.4			
Airfields.....	0.4	0.6	1.0			
Institutions.....	2.0	---	2.0			
Streets and sidewalks.....	---	0.5	0.5			
Vacant lots.....	---	1.2	1.2			
Weighted average.....	1.4	0.3	1.7	1.4	0.3	1.7
Farmstead and miscellaneous						
Farmstead.....	1.0	1.0	2.0	1.0	1.0	2.0
Roads and railroads.....			0.7			0.7
Water surface.....			4.0			4.0

Records of such application of water pumped from wells were obtained for 106 plots during 1947-48, and for 40 plots during 1948-49. For each well, the pump discharge, acreage of each type of crop irrigated, number of irrigations, period of irrigation, and amounts of water applied in each irrigation were recorded. From these data, monthly and total seasonal applications of water to each crop were determined. Detailed results of these studies are given in Appendix J, and location of the plots is indicated on Plate 16. Estimates of weighted seasonal application of ground water on representative plots of principal crops, based on the foregoing detailed studies and on other studies conducted in comparable areas having similar crops, are presented in Table 30 for

the forebay and pressure zones of the Santa Clara Valley. These estimates were utilized in the determination of total applied water to irrigated crops.

TABLE 30

ESTIMATED WEIGHTED MEAN SEASONAL APPLICATION OF GROUND WATER TO PRINCIPAL CROPS IN SANTA CLARA VALLEY

(In feet of depth)

Crop	Applied water	
	Forebay zones	Pressure zones
Alfalfa.....	2.7	2.8
Beans.....	1.1	1.1
Deciduous orchard.....	2.1	1.4
Permanent pasture.....	2.6	2.6
Sugar beets.....	1.8	1.3
Tomatoes.....	1.5	1.5
Truck.....	2.4	2.7
Vineyard.....	1.2	1.0

Urban draft on ground water in North Santa Clara Valley was estimated from data obtained by the Division of Water Resources in connection with the State-wide Water Resources Investigation. Unit values of urban water requirement were determined from surveys of water use in typical areas for each of the types of urban land use. Water meter readings for a 12-month period in 1948-49 were obtained from water supply agencies serving the areas, and unit values of water use were computed.

Unit values of water requirement, estimated by the foregoing method, were applied to the urban areas of San Jose, Sunnyvale, Mountain View, Los Altos, Cupertino, and Monte Vista, and the resulting totals were compared with measured deliveries of water. Some adjustments in the unit values were required so that derived values agreed with measured deliveries. These adjusted derived values were considered also applicable to urban areas in South Santa Clara Valley.

A summary of the derived unit values of urban draft on ground water, resulting from the foregoing studies, is shown in Table 31. This table presents estimated metered deliveries of water on net developed areas, and required draft on ground water for net developed areas. The unit values of draft on ground water are based on an assumed 10 per cent conveyance loss in distribution systems. This rate of loss was generally substantiated by records of the San Francisco Water Department and the East Bay Municipal Utility District.

Based on the data presented in Tables 30 and 31, it was estimated that the total application of ground water during the 1947-48 season in North and South Santa Clara Valleys was about 225,000 acre-feet. As a check on this figure, the Pacific Gas and Electric Company and the Coast Counties Gas and Electric

TABLE 31
ESTIMATED PRESENT UNIT VALUES OF URBAN DRAFT
ON GROUND WATER IN SANTA CLARA VALLEY
(In feet of depth)

Type of urban use	Gross draft	De-livered to meter	Requirement	
			Forebay zones	Pressure zones
Residential (one- and two-family dwellings).....	2.2	2.0	2.0	2.2
Multiple-family residential (three or more families).....	6.6	6.0	6.0	6.6
Commercial.....	4.4	4.0	4.0	4.4
Industrial.....	8.8	8.0	8.0	8.8
Irrigated parks.....	1.1	1.0	1.0	1.1
Institutions.....	2.2	2.0	2.0	2.2
Airfields.....	0.4	0.4	0.4	0.4

Company, now owned by the Pacific Gas and Electric Company, furnished records of electrical power consumption for pumping, from which it was estimated that ground water pumping was 233,000 acre-feet in North and South Santa Clara Valleys. The estimate based on data furnished by the companies gave consideration to the relationship between pumping plant horsepower, drawdown, and power consumption per unit of water pumped at various lifts, as determined by pump performance tests conducted in the valley by the companies. In view of the nature of the basic data, the check indicated was believed to have been very close.

Past and Present Water Requirements

In both North and South Santa Clara Valleys the basic ground water basins are the free ground water or forebay zones. Ground water in these zones not only constitutes the source of water pumped for use on overlying lands, but the free ground water basins also serve as reservoirs from which flow enters the confined aquifers of the pressure zones to supply most of the extractions therefrom. The physical characteristics of the forebay zones permit unused portions of precipitation, stream flow, and irrigation water to percolate to the water table, where the waters are available for future use or re-use. However, this is not true of the pressure zones, since relatively impermeable clay strata prevent surface waters from reaching the principal water-yielding aquifers.

The total present water requirement, as determined for the Santa Clara Valley, includes consumptive use of water in the forebay zones plus the draft on ground water in the pressure zones, during the base periods, and under mean conditions of water supply with 1948 development. These quantities were estimated by multiplying the acreage of each type of land use by its respective unit value of consumptive use of water in the forebay zones, and unit draft on ground water in the pressure zones. The total consumptive use of precipitation and applied water in

the forebay zones, added to draft on ground water in the pressure zones, gave the amount of the seasonal water requirement met by the forebay zones.

It was estimated that the water requirement met from the forebay zone of North Santa Clara Valley averaged about 274,100 acre-feet per season during the 13-year base period. With 1948 conditions of development, it was estimated that the total mean seasonal water requirement met from the forebay zone would have been about 297,200 acre-feet, an increase of about eight per cent above the actual base period average. The increase can be attributed to expansion of the areas of land under irrigation or urban development, and corresponding decrease in the area of nonirrigated lands. This estimate is presented in Table 32.

TABLE 32
ESTIMATED PAST AND PRESENT SEASONAL WATER
REQUIREMENTS MET FROM FOREBAY ZONE
OF NORTH SANTA CLARA VALLEY

Class of land use	Weighted mean seasonal unit water requirement, in feet of depth	Average for 13-year base period, 1935-36 through 1947-48		Mean with 1948 land use	
		Area, in acres	Total water requirement, in acre-feet	Area, in acres	Total water requirement, in acre-feet
Forebay Zone					
Irrigated lands.....	2.5	53,300	133,200	58,500	146,200
Nonirrigated lands.....	1.6	23,300	37,300	15,800	25,300
Urban areas.....	1.7	4,200	7,100	6,400	10,900
Farmsteads.....	2.0	600	1,200	700	1,400
Miscellaneous.....	1.0	5,100	5,100	5,100	5,100
Subtotals.....		86,500	183,900	86,500	188,900
Pressure Zone					
Irrigated lands.....	1.8	39,000	70,200	41,900	75,400
Nonirrigated lands.....	0	23,500	0	13,300	0
Urban areas.....	1.8	10,400	18,700	17,500	31,500
Farmsteads.....	1.2	1,100	1,300	1,200	1,400
Miscellaneous.....	0	4,600	0	4,700	0
Subtotals.....		78,600	90,200	78,600	108,300
TOTALS.....		165,100	274,100	165,100	297,200

It was estimated that in South Santa Clara Valley the seasonal water requirement met from the forebay zone averaged about 82,300 acre-feet during the 16-year base period, with a mean value of about 86,900 acre-feet per season under 1948 conditions of development. The increase in water requirement may be attributed to an expansion of area under agricultural and urban water service. A summary of this estimate is presented in Table 33.

As has been stated, the net seasonal draft on ground water in North and South Santa Clara Valleys was estimated by adding the consumptive use of applied water in the forebay zones to the total draft of ground water in the pressure zones. In North

TABLE 33

**ESTIMATED PAST AND PRESENT SEASONAL WATER
REQUIREMENTS MET FROM FOREBAY ZONE
OF SOUTH SANTA CLARA VALLEY**

Class of land use	Weighted mean seasonal unit water requirement, in feet of depth	Average for 16-year base period, 1932-33 through 1947-48		Mean with 1948 land use	
		Area, in acres	Total water requirement, in acre-feet	Area, in acres	Total water requirement, in acre-feet
Forebay Zone					
Irrigated lands.....	2.5	13,800	34,500	15,400	38,500
Nonirrigated lands.....	1.4	14,700	20,600	12,900	18,100
Urban areas.....	1.7	600	1,000	800	1,400
Farmsteads.....	2.0	300	600	300	600
Miscellaneous.....	0.7	2,400	1,700	2,400	1,700
Subtotals.....		31,800	58,400	31,800	60,300
Pressure Zone					
Irrigated lands.....	1.8	12,900	23,200	14,300	25,700
Nonirrigated lands.....	0	5,200	0	3,700	0
Urban areas.....	1.7	200	300	300	500
Farmsteads.....	1.2	300	400	300	400
Miscellaneous.....	0	1,800	0	1,800	0
Subtotals.....		20,400	23,900	20,400	26,600
TOTALS.....		52,200	82,300	52,200	86,900

TABLE 34

**ESTIMATED AVERAGE AND MEAN SEASONAL DRAFT ON
GROUND WATER IN NORTH SANTA CLARA VALLEY**

Class of land use	Unit seasonal draft, in feet of depth	Average for 13-year base period, 1935-36 through 1947-48		Mean with 1948 land use	
		Area, in acres	Total draft, in acre-feet	Area, in acres	Total draft, in acre-feet
Forebay Zone					
Irrigated lands.....	1.2	53,300	64,000	58,500	70,200
Nonirrigated lands.....	0	23,300	0	15,800	0
Urban areas.....	1.4	4,200	5,900	6,400	9,000
Farmsteads.....	1.0	600	600	700	700
Miscellaneous.....	0	5,100	0	5,100	0
Subtotals.....		86,500	70,500	86,500	79,900
Pressure Zone					
Irrigated lands.....	1.8	39,000	70,200	41,900	75,400
Nonirrigated lands.....	0	23,500	0	13,300	0
Urban areas.....	1.8	10,400	18,700	17,500	31,500
Farmsteads.....	1.2	1,100	1,300	1,200	1,400
Miscellaneous.....	0	4,600	0	4,700	0
Subtotals.....		78,600	90,200	78,600	108,300
TOTALS.....		165,100	160,700^a	165,100	188,200^b

^a Includes 2,000 acre-feet of imported water, and 3,900 acre-feet diverted from Saratoga and Los Gatos Creeks.

^b Includes 4,000 acre-feet of imported water, and 5,000 acre-feet diverted from Saratoga and Los Gatos Creeks.

Santa Clara Valley the estimated net draft on ground water averaged about 154,800 acre-feet per season during the 13-year base period, and 179,200 acre-feet under mean conditions of water supply and 1948 land use. Table 34 presents a summary of these estimates. It will be noted that the total seasonal draft on ground water for the base period, and the mean value with 1948 land use, exceed the foregoing estimates by 5,900 and 9,000 acre-feet, respectively. The excess in each case represents the sum of the average seasonal importation of water and the water diverted from Saratoga and Los Gatos Creeks.

The total seasonal draft on ground water in South Santa Clara Valley was estimated to have been about 41,600 acre-feet during the 16-year base period, and approximately 46,400 acre-feet under mean conditions of water supply and with 1948 development. Table 35 presents a summary of these estimates of total seasonal draft on ground water in South Santa Clara Valley.

TABLE 35

**ESTIMATED AVERAGE AND MEAN SEASONAL DRAFT ON
GROUND WATER IN SOUTH SANTA CLARA VALLEY**

Class of land use	Unit draft, in feet of depth	Average for 16-year period, 1932-33 through 1948-49		Mean with 1948 land use	
		Area, in acres	Total draft, in acre-feet	Area, in acres	Total draft, in acre-feet
Forebay Zone					
Irrigated lands.....	1.2	13,900	16,700	15,400	18,500
Nonirrigated lands.....	0	14,600	0	12,900	0
Urban areas.....	1.2	600	700	800	1,000
Farmsteads.....	1.0	300	300	300	300
Miscellaneous.....	0	2,400	0	2,400	0
Subtotals.....		31,800	17,700	31,800	19,800
Pressure Zone					
Irrigated lands.....	1.8	12,900	23,200	14,300	25,700
Nonirrigated lands.....	0	5,200	0	3,700	0
Urban areas.....	1.7	200	300	300	500
Farmsteads.....	1.2	300	400	300	400
Miscellaneous.....	0	1,800	0	1,800	0
Subtotals.....		20,400	23,900	20,400	26,600
TOTALS.....		52,200	41,600	52,200	46,400

Probable Ultimate Water Requirement

The population of Santa Clara County increased from about 60,000 in 1900 to about 291,000 in 1950. As has been stated, this growth was accompanied by substantial agricultural development. However, in recent years the desirability of North Santa Clara Valley for residential and industrial development has become a more important factor. Many orchards and other irrigated lands have been replaced by subdivisions within the last decade. Some of the urban expansion has been spurred by enhancement of job op-

portunities elsewhere within the San Francisco Bay area. However, a large part of the change in economy has been caused by progressive development of established industries in Santa Clara County, and to the introduction of new industries in the area. In view of these circumstances, and since continued expansion seems inevitable, it was assumed that under probable ultimate conditions of development North Santa Clara Valley will be largely urban.

The economic stimulus provided by growth of North Santa Clara Valley and other areas in the San Francisco Bay area should contribute to further development of South Santa Clara Valley. However, this valley is not as favorably located with respect to present major urban areas as is the northern valley. It was assumed, therefore, that while most of the southern valley floor lands will ultimately require water service, the ultimate proportions of urban and irrigated agricultural developments, as well as crop patterns within the latter group, will equal the present proportions.

The total probable ultimate water requirement in the Santa Clara Valley has been defined heretofore as the sum of consumptive use of applied water in the forebay zones, plus the draft on ground water in the pressure zones, under ultimate conditions of development. By applying appropriate unit values of water requirement to the estimated ultimate land use pattern, it was estimated that this would be about 466,100 acre-feet per season. Of this total quantity about 405,500 acre-feet would be utilized each season in North Santa Clara Valley, while about 60,600 acre-feet would be used in South Santa Clara Valley.

TABLE 36

PROBABLE ULTIMATE MEAN SEASONAL WATER REQUIREMENT IN NORTH SANTA CLARA VALLEY

Class of land use	Unit water requirement, in feet of depth	Area, in acres	Total water requirement, in acre-feet
Forebay Zone			
Irrigated lands.....	0	0	0
Urban areas.....	1.9	83,400	158,500
Farmsteads.....	0	0	0
Miscellaneous.....	0	3,100	0
Subtotals.....		86,500	158,500
Pressure Zone			
Irrigated lands.....	1.8	7,300	13,100
Urban areas.....	2.7	67,600	182,500
Farmsteads.....	1.2	200	200
Miscellaneous.....	0	3,500	0
Subtotals.....		78,600	195,800
Habitable hills and marshlands			
Hills.....	1.0 ^a	40,400	40,400
Marshlands.....	2.7	4,000	10,800
Subtotals.....		44,400	51,200
TOTALS.....		209,500	405,500

^a Reduced by one-half to allow for low density.

Tables 36 and 37, respectively, summarize the estimates of probable ultimate water requirement in North and South Santa Clara Valleys.

TABLE 37

PROBABLE ULTIMATE MEAN SEASONAL WATER REQUIREMENT IN SOUTH SANTA CLARA VALLEY

Class of land use	Unit water requirement, in feet of depth	Area, in acres	Total water requirement, in acre-feet
Forebay Zone			
Irrigated lands.....	1.2	22,000	26,400
Urban areas.....	1.4	1,200	1,700
Farmsteads.....	1.0	400	400
Miscellaneous.....	0	8,200	0
Subtotals.....		31,800	28,500
Pressure Zone			
Irrigated lands.....	1.8	17,300	31,100
Urban areas.....	1.7	300	500
Farmsteads.....	1.2	400	500
Miscellaneous.....	0	2,400	0
Subtotals.....		20,400	32,100
TOTALS.....		52,200	60,600

Nonconsumptive Water Requirements

Certain nonconsumptive requirements for water, such as those for flood control, recreation, and conservation of fish and wildlife, will be of significance in the design of works to meet requirements for water in Santa Clara Valley. In most instances the magnitudes of the nonconsumptive requirements are relatively indeterminate, and are dependent upon allocations to be made during design of the works and after consideration of economic factors. Water requirements for flood control, recreation, and conservation of fish and wildlife are discussed in general terms in this section, but not specifically evaluated.

Flood Control. Destruction and havoc caused by floods in California have frequently been accompanied by the economic anomaly of wastage of large amounts of water from areas of deficient water supply. Storage of such flood waters in upstream reservoirs would have accomplished the dual purpose of conservation of needed water and reduction of flood damages. Results of the State-wide Water Resources Investigation to date indicate that if California is to attain growth and development commensurate with her manifold resources, nearly all of the potential reservoir storage capacity of the State must be constructed and dedicated to operation for water conservation purposes. This in itself will result in a substantial increase in downstream flood protection. However, any portion of the available reservoir storage capacity that is operated wholly or partially for flood control purposes will correspondingly reduce the capacity available for conservation.



Anderson Reservoir
on Coyote Creek



Anderson Dam
on Coyote Creek

No space in reservoirs constructed by the Santa Clara Valley Water Conservation District in North Santa Clara Valley is specifically dedicated to flood control, and only incidental flood protection is realized from their operation. Although such operation may reduce the frequency of flood occurrence, it may also create a false sense of security conducive to encroachment on flood plains, with resultant greater damage during the less frequent occasions of flooding by reservoir spill.

A major problem confronting North Santa Clara Valley is the problem of disposal of storm drainage from urban and industrial developments. These developments have, in some instances, been located on poorly drained areas and have encroached on stream channels and tidal flats, which formerly provided a means for the disposal of flood waters. Increased urbanization has also augmented storm runoff. Plans for development of lands in North Santa Clara Valley should provide for the control and disposal of all flood waters along and adjacent to main stream channels, and should also provide for the collection of storm drainage, particularly within areas devoted to urban development, and its delivery to flood channels.

The area extending south and east from Gilroy to the Pajaro River in South Santa Clara Valley has been subject to destructive floods five times since 1937. The lands flooded were subjected to inundation for a long period, which greatly restricts their adaptability to cropping. Along Llagas Creek, east of Gilroy and San Martin in South Santa Clara Valley, old drainage channels have been obstructed, which, during periods of flood flow results in the waterlogging of adjacent orchard lands. Solution to the flood control problems in South Santa Clara Valley includes channel clearing, bank protection, levees, and drain ditches for removal of water from submerged and waterlogged areas.

Recreation and Fish and Wildlife. With anticipated continued growth in population of California, it is expected that the public demand for preservation and enhancement of recreational facilities will be sufficient to assure provision of water supplies necessary for such purposes. In the aggregate the amount of water used for domestic and service facilities in recreational areas in watersheds tributary to the Santa Clara Valley is relatively small. As for waters employed for boating, swimming, and other water sports, most are available naturally or as a result of works constructed and operated for other purposes, and the nonconsumptive recreational use of the water is incidental to the other uses. Of considerable importance among the employments of water for recreational purposes are those associated with the preservation and propagation of fish and wildlife.

So far as is known, no artificial lakes in watersheds tributary to the Santa Clara Valley are utilized exclusively for fish life, such use being incidental to the

primary purposes for which the reservoirs were constructed.

Water released down a stream to maintain the minimum flow required for fish life does not constitute a consumptive use of the water. The demands of fish life, however, are frequently incompatible with diversion and use of the water for other beneficial purposes. However, reservoirs constructed to regulate stream flows for other purposes will provide a greatly increased lake fishery.

Factors of Water Demand

Factors of water demand, as used in this bulletin, refer to rates, times, and places of delivery of water, losses of water, quality of water, etc., imposed by the control, development, and use of the water for beneficial purposes. Irrigation practices in the Santa Clara Valley, as determined by irrigation efficiency, monthly demands, and permissible deficiencies in application of water, must be given consideration in preliminary design of works to meet supplemental water requirements. Similar consideration must be given to monthly demands in urban water supply development. These demand factors, which were not measured or considered in the foregoing estimates of water requirements, are discussed in the following sections.

Irrigation Efficiency. Studies were made to determine the approximate average irrigation efficiency realized from application of ground water in the Santa Clara Valley. Irrigation efficiency is defined as the ratio of consumptive use of applied water to the total amount of applied water, and is commonly expressed as a percentage.

The season of 1947-48 was selected for these studies, since in that season the coverage of plot studies of application of water was the most comprehensive. In order to estimate the total amount of ground water applied for irrigation, appropriate crop acreages, as mapped during the 1948 land use survey, were multiplied by average seasonal values of depth of applied water for the several crops, as presented in Table 30. The computation of applied ground water in the Forebay Zone of North Santa Clara Valley resulted in an estimate of about 121,900 acre-feet, whereas in the Forebay Zone of South Santa Clara Valley it was about 31,200 acre-feet.

By dividing the estimated values of 70,200 acre-feet and 18,500 acre-feet, for consumptive use of ground water in the forebay zones of North and South Santa Clara Valleys, respectively, by the foregoing estimated values for applied ground water, it was estimated that irrigation efficiencies realized from the application of ground water in the respective forebay zones in 1947-48 was approximately 58 per cent and 61 per cent.

Monthly Demands for Water. Irrigation demands for water in the Santa Clara Valley are seasonal in

nature, being confined chiefly to the period from May through October. The maximum rate of demand occurs during the months of June and July when nearly 37 per cent of the total seasonal demand occurs. On the other hand, the demand pattern for urban water is continuous throughout the season, with a relatively smaller variation between the maximum and minimum monthly rates.

Estimated monthly irrigation and urban demands for water in the Santa Clara Valley, in percentages of the seasonal totals, are presented in Table 38. The values for irrigation were based on average monthly agricultural power sales of the San Jose Division of the Pacific Gas and Electric Company for the period from 1947 through 1951. Urban values were based on the averages of records of monthly deliveries of water for urban purposes to San Jose, Mountain View, Campbell, Santa Clara, and Sunnyvale, for the period from 1948 through 1953.

TABLE 38
ESTIMATED AVERAGE MONTHLY DISTRIBUTION
OF SEASONAL DEMANDS FOR WATER
IN SANTA CLARA VALLEY
(In percent of seasonal total)

Month	Irrigation	Urban
October.....	12	8
November.....	5	6
December.....	1	5
January.....	0	5
February.....	1	5
March.....	2	6
April.....	3	7
May.....	10	10
June.....	19	11
July.....	18	13
August.....	13	13
September.....	16	11
TOTALS.....	100	100

Permissible Deficiencies in Application of Water.

Studies to determine deficiencies in the supply of irrigation water that may be endured without permanent injury to perennial crops were not made in connection with the Santa Clara Valley Investigation. However, the results of past investigation and study of endurable deficiencies in the Sacramento River Basin may be of interest, insofar as they may relate to the Santa Clara Valley. In this respect the following is quoted from Division of Water Resources Bulletin No. 26, "Sacramento River Basin," 1931.

"... A full irrigation supply furnishes water not only for the consumptive use of the plant but also for evaporation from the surface during application and from the moist ground surface, and for water which is lost through percolation to depths beyond the reach of the plant roots. Less water can be used in years of deficiency in supply by careful application and by more thorough cultivation to conserve the ground moisture. In

these ways the plant can be furnished its full consumptive use with much smaller amounts of water than those ordinarily applied and the yield will not be decreased. If the supply is too deficient to provide the full consumptive use, the plant can sustain life on smaller amounts but the crop yield will probably be less than normal.

"It is believed from a study of such data as are available that a maximum deficiency of 35 per cent of the full seasonal requirement can be endured, if the deficiency occurs only at relatively long intervals. It is also believed that small deficiencies occurring at relatively frequent intervals can be endured . . ."

In the design of works to meet urban water demands, it is common practice to provide for a full water supply without deficiency at any time. However, it has been the experience of many communities in California that substantial deficiencies may be endured for extended periods of time by rationing the limited water supplies at hand. No information is available regarding the economic effects of such rationing of urban water. In the Santa Clara Valley, deficiencies in surface water supplies can be met by pumping from the ground water basin.

SUPPLEMENTAL WATER REQUIREMENTS

The previously presented data, estimates, and discussion regarding water supply and requirement in the Santa Clara Valley indicate that the present and probable future water problems of the area are largely limited to those connected with ground water, and that their effects in North Santa Clara Valley are largely related to urban development, and in South Santa Clara Valley to irrigated agriculture. It is further indicated that ground water problems, created in various portions of the area by progressive lowering of water levels, may be limited or prevented if adequate supplemental water supplies are developed and utilized in the area. The present and probable ultimate requirements for supplemental water in the Santa Clara Valley are discussed and evaluated in the following sections. As previously defined, requirements for supplemental water refer to the amount of water, over and above the sum of safe ground water yield and safe surface water yield, which must be developed to satisfy water requirements. Water requirements in turn refer to the amount of water needed to provide for all beneficial consumptive use of water and for irrecoverable losses of water incidental to such beneficial use.

Present Supplemental Water Requirement

The present requirement for supplemental water in the Santa Clara Valley was evaluated as the difference between safe yield of ground water and present draft on ground water.

It was estimated in Chapter II that the safe seasonal ground water yield from the Forebay Zone of North Santa Clara Valley amounts to about 134,400 acre-feet, and from the Forebay Zone of South Santa Clara Valley to about 39,300 acre-feet. These values were determined as the seasonal draft of water from the ground water basins which might be maintained, under mean conditions of water supply and climate, without further progressive lowering of water levels below average levels prevailing during the respective base periods in North and South Santa Clara Valleys. It was further estimated that the safe seasonal ground water yields in the respective pressure zones of North and South Santa Clara Valleys amount to 84,300 acre-feet and 26,600 acre-feet, respectively.

Seasonal draft on ground water in North Santa Clara Valley, with the present pattern of land use and under mean conditions of water supply and climate, was estimated to be 179,200 acre-feet, of which 170,000 acre-feet is supplied from the Forebay Zone and the remaining 9,200 acre-feet from aquifers beneath San Francisco Bay. The estimated total present requirement for supplemental water, therefore, is some 44,800 acre-feet per season. However, the safe yield of the Pressure Zone, as defined in Chapter II, is limited by the maximum rate of pumping draft which can be sustained, during the height of the pumping season, without inducing intrusion of water from beneath San Francisco Bay into the confined aquifers of the zone. On this basis, the seasonal safe yield of the pressure zone aquifers was estimated to be about 84,300 acre-feet with the monthly pumping demand pattern that existed during the 1948 pumping season. The present mean seasonal pumpage from the confined aquifers of the Pressure Zone was estimated to be 104,300 acre-feet. Therefore, the present requirement for supplemental water in the Pressure Zone, the difference between safe yield and pumpage of ground water, amounts to an estimated 20,000 acre-feet per season. The estimated present seasonal requirement for supplemental water in the Forebay Zone of North Santa Clara Valley is 24,800 acre-feet, the difference between the total supplemental requirement and that of the Pressure Zone.

Seasonal draft on ground water in South Santa Clara Valley, with the present pattern of land use and under mean conditions of water supply and climate, was estimated to be 46,400 acre-feet, as shown in Table 35. The estimated total present requirement for supplemental water in South Santa Clara Valley, therefore, is about 7,100 acre-feet per season. The safe yield of the Pressure Zone, as in the case of the Pressure Zone of the northern valley, is limited by the maximum rate of pumping draft which can be sustained during the height of the pumping season without resulting in the formation of a ground water

trough. On this basis the safe seasonal yield was estimated to be about 26,600 acre-feet, with the monthly pumping demand pattern that existed during the 1948 pumping season. The present mean seasonal pumpage from the confined aquifers of the Pressure Zone was estimated also to be 26,600 acre-feet. Therefore, it is indicated that there is no present requirement for supplemental water in the Pressure Zone of South Santa Clara Valley.

Probable Ultimate Supplemental Water Requirement

As has been stated, the probable ultimate requirement for supplemental water in the Santa Clara Valley was evaluated as the difference between present and probable ultimate draft on ground water, plus the present requirement for supplemental water. Development and utilization of a supplemental water supply in the amount of this forecast would assure an adequate supply of water for lands presently receiving water service, as well as for those additional lands which will receive water in the future. Furthermore, present problems resulting from progressive lowering of ground water levels and threat of seawater intrusion from beneath San Francisco Bay would be eliminated.

Estimates of present and probable ultimate draft on ground water in North and South Santa Clara Valleys, under mean conditions of water supply and climate, have been presented in Tables 34, 35, 36, and 37, and a corresponding estimate of the present requirement for supplemental water was developed in the preceding section. Utilizing these estimates, the forecasts of probable ultimate seasonal requirement for supplemental water in North and South Santa Clara Valleys, under mean condition of water supply and climate, are presented in Table 39.

TABLE 39
PROBABLE ULTIMATE MEAN SEASONAL SUPPLEMENTAL
WATER REQUIREMENTS IN SANTA CLARA VALLEY

Division	(In acre-feet)				
	1	2	3	4	5
	Present draft on ground water	Probable ultimate water requirement	Probable increase in water requirement (2 — 1)	Present supplemental requirement	Probable ultimate supplemental water requirement (3 + 4)
North Santa Clara Valley ---	188,200*	405,500	217,300	44,800	262,100
South Santa Clara Valley ----	46,400	60,600	14,200	7,100	21,300
TOTALS -----	234,600	466,100	231,500	51,900	283,400

* Includes 4,000 acre-feet of imported water, and 5,000 acre-feet diverted from Saratoga and Los Gatos Creeks.

The foregoing estimate of probable ultimate supplemental water requirement does not take into account the yield of certain local projects which have been constructed and put into operation since the base period. Studies described in sections of the bulletin which follow indicate that the seasonal yield of these projects is about 45,000 acre-feet. In addition, certain projects are described, which if constructed

would provide additional water. Of these projects, the Northern Valley Project and the Uvas and Llagas Creeks Project appear most likely to be constructed. Assuming construction of these two projects, which would provide a seasonal yield of 25,000 acre-feet of water, it is indicated that a seasonal import of about 213,000 acre-feet of water will be required to satisfy ultimate water requirements in the Santa Clara Valley.

CHAPTER IV

PLANS FOR WATER DEVELOPMENT

It has been shown heretofore that the present basic water problems in the Santa Clara Valley are progressive and permanent lowering of ground water levels, and the threat of sea-water intrusion from beneath San Francisco Bay to aquifers of the pressure zone of North Santa Clara Valley. Elimination of these problems, prevention of their recurrence in the future, and the provision of water for lands not presently served will require the further conservation of local water supplies, and the importation of water from an outside source or sources. In the preceding chapter, estimates were presented as to the amount of supplemental water required for these purposes, both at the present time and under probable ultimate conditions of development.

It has been shown that surplus flows of water are presently available to the Santa Clara Valley from certain local streams. This surface water is available during the winter and spring months of nearly every season. Studies which are described in this chapter indicate that the surplus flows, if properly controlled and regulated, would meet the present requirement for supplemental water in North Santa Clara Valley, and would meet the probable ultimate requirement for supplemental water in South Santa Clara Valley.

As was stated in Chapter I, the Division of Water Resources is presently conducting surveys and studies for the State-wide Water Resources Investigation, under the direction of the State Water Resources Board. This investigation has as its objective the formulation of The California Water Plan, for full conservation, control, protection, and utilization of the State's water resources, to meet present and future water needs for all beneficial purposes and uses in all parts of the State, insofar as practicable. Although this investigation is still in progress, it is sufficiently advanced to permit tentative description of certain proposed major features of The California Water Plan which could provide supplemental water to meet the probable ultimate requirements of the Santa Clara Valley. These projects would also provide supplemental water supplies for many other water-deficient areas of California. In addition, benefits from the projects would include hydroelectric power, flood and salinity control, mining debris storage, and benefits in the interests of recreation and the preservation of fish and wildlife.

In general, the cited major features of The California Water Plan would be large multipurpose projects requiring relatively large capital expenditures.

Their scope, with regard to both location of the works and benefits derived from their operation, would not be limited to any one local area, but would embrace considerable portions of California. In light of these facts, and in view of the remaining undeveloped local water supply, surveys and studies were made in order to estimate costs of supplemental water supplies for the Santa Clara Valley under more localized plans, that might be suitable for current financing, construction, and operation by appropriate local public agencies. These plans for initial development generally are such that the works could be integrated into future major projects. Their purposes are largely limited to conservation of new water supplies sufficient to meet the present requirements for supplemental water in North Santa Clara Valley, and sufficient to meet the probable ultimate requirements for supplemental water in South Santa Clara Valley.

Major features of The California Water Plan which might be pertinent to solution of the ultimate water problems of the Santa Clara Valley are described in general terms in this chapter under the heading "The California Water Plan." The several plans considered for possible local development of supplemental water supplies are described under the heading "Plans for Initial Local Development," and locations of their principal features are shown on Plate 17, entitled "Existing Water Conservation Works and Works Considered for Future Development." Those of the local plans that were found to be the most favorable for initial development are presented in some detail in this chapter, together with estimates of their capital and annual costs, and unit costs of the developed supplemental water supplies. All of the plans considered would be subject to vested rights.

THE CALIFORNIA WATER PLAN

The Feather River Project, an adopted feature of The California Water Plan, could provide supplemental water to partially meet the probable ultimate requirement of the Santa Clara Valley. The Hetch Hetchy system of the City of San Francisco could provide supplemental water to meet the municipal requirements in North Santa Clara Valley. Consideration also has been given to the possibility of obtaining supplemental water for the Santa Clara Valley from the pool behind a possible salt-water barrier located in the north arm of San Francisco Bay. In addition, consideration has been given to the

feasibility of reclaiming and conveying sewage from the City of San Francisco, peninsula cities and communities, and San Jose, for irrigation use in the Santa Clara Valley.

Feather River Project

The probable ultimate supplemental water requirement in the Santa Clara Valley could be partially met under a plan which would provide regulatory storage on the Feather River near Oroville in the Sacramento Valley, and conveyance of a portion of the regulated water supply across the Sacramento-San Joaquin Delta, through Brushy Peak, thence through Livermore Valley to the Santa Clara Valley. Such storage and conveyance facilities would be made available by construction of works which are described in detail in a publication of the State Water Resources Board, entitled "Report on Feasibility of Feather River Project, and Sacramento-San Joaquin Delta Diversion Projects, Proposed as Features of The California Water Plan," dated May, 1951. These projects were authorized and adopted by the 1951 Legislature, in an act which authorized their construction, operation, and maintenance by the Water Project Authority of the State of California. Subsequently, more detailed studies have indicated some modification in certain of the storage and conveyance facilities described in the feasibility report. These are described in a publication of the Division of Water Resources, entitled "Program For Financing and Constructing The Feather River Project as The Initial Unit of The California Water Plan," February, 1955.

This recent publication indicates that water would be released from Oroville Reservoir down the Feather and Sacramento Rivers to the Sacramento-San Joaquin Delta, where it would firm presently existing supplies. The water would be conveyed across the Delta through the Delta Cross Channel, and diverted to the Santa Clara Valley from Old River in the San Joaquin River Delta near the Alameda-Contra Costa county line. The water would be lifted by pumping to a main canal located at an elevation of about 230 feet. This canal would parallel the Delta-Mendota Canal of the Central Valley Project. Two miles south of the pump lift from Old River a portion of the water would be diverted into the Alameda-Santa Clara-San Benito Branch of the Feather River Project Aqueduct. This water would be lifted to an elevation of about 705 feet, to a canal leading to the portal of a tunnel, 7,500 feet in length, through Brushy Peak. General features of this branch are shown on Plate 18, entitled "The Alameda-Santa Clara-San Benito Branch of the Feather River Project Aqueduct, 1955."

From the western portal of the tunnel through Brushy Peak, a concrete-lined canal would carry the water around the east and south sides of Livermore

Valley to a tunnel, 3,400 feet in length, through Rocky Ridge. Rocky Ridge is located about 4 miles south of Livermore. A reinforced-concrete pipe would convey the water westerly from the end of the tunnel through Rocky Ridge to a 1,300-foot tunnel at Mission Pass. From the end of the Mission Pass Tunnel the pipe conduit would continue southerly, above Mission San Jose and Warm Springs, to the proposed Airpoint regulating reservoir on the Arroyo De Los Coches. Airpoint Reservoir, with storage capacity of 23,000 acre-feet, would be located in Santa Clara County about 2 miles east of Milpitas, and the maximum elevation of the water surface in the reservoir would be 615 feet.

From Airpoint Reservoir a pipe conduit would extend in a southeasterly direction, crossing Alum Rock Park, to a proposed regulating reservoir near Evergreen on Silver Creek, about 6 miles southeast of San Jose. The maximum elevation of the water surface in this reservoir would be about 540 feet, and the reservoir storage capacity would be about 32,500 acre-feet.

From Evergreen Reservoir a conduit, consisting mostly of canal, would extend southeasterly along the base of the hills on the eastern side of the Santa Clara Valley to a terminus on Pacheco Creek, just south of the Santa Clara-San Benito county line. The water surface elevation at the terminus would be about 380 feet. The distance from the intake on the main Feather River Project Aqueduct to the terminus of the canal at Pacheco Creek is approximately 108 miles.

A pressure pipe lateral would start at a turnout on the main conduit about 1 mile northwest of Evergreen Dam, at an elevation of 450 feet. It would traverse the Santa Clara Valley, passing about 7 miles south of San Jose, and continue westerly to the vicinity of Saratoga, and thence along the base of the foothills in a southwesterly direction, passing near Monte Vista and Los Altos to a terminus at Felt Reservoir, at a maximum water surface elevation of 380 feet. The total length of the lateral would be about 30 miles.

As a basis for estimating costs for the Feather River Project, it was considered that the Alameda-Santa Clara-San Benito Branch of the Feather River Project Aqueduct would be constructed in two stages. The first stage would provide 120,000 acre-feet of water per season to San Benito County, the Santa Clara Valley, the bayside area of Alameda County, and Livermore Valley. The second stage would provide an additional 120,000 acre-feet of water per season to these areas. In the financial analyses made for the Feather River Project, it was indicated that a charge of from \$17.50 per acre-foot to \$22.50 per acre-foot would be required for delivery of water from the Alameda-Santa Clara-San Benito Branch,

depending upon the assumptions as to interest rate, period of repayment, and other relevant factors.

Based upon historical records of flows of fresh water into San Francisco Bay, sufficient supplemental water could be supplied by the Feather River Project to meet in part the ultimate requirements of Alameda County, the Santa Clara Valley, and San Benito County, without impairment of existing demands upon and presently contemplated maximum exportations of water from the Sacramento-San Joaquin Delta. Such demands include those for salinity control as well as for irrigation. The plan for the diversion of a water supply from Old River in the Sacramento-San Joaquin Delta is feasible from an engineering point of view.

Analyses show that the chemical quality of water at different locations in the Sacramento-San Joaquin Delta is Class 1 for irrigation, and that it falls well within accepted standards for drinking water. However, for domestic and municipal uses the water would require bacteriological treatment and filtration, as do practically all raw waters.

Other Plans Under Consideration

A possible source of water supply for North Santa Clara Valley is the Hetch Hetchy system of the City of San Francisco, which diverts waters of the Tuolumne River in the Sierra Nevada, conserved in Hetch Hetchy and Eleanor Reservoirs, and conducts this water a distance of about 155 miles to a service area which includes most cities and communities of the San Francisco Peninsula south to and including Palo Alto. Construction of Cherry Valley Reservoir on Cherry Creek, a tributary of the Tuolumne River, is near completion, and will augment the water supply of the system. Present capacity of the Hetch Hetchy system is 136,000,000 gallons of water daily, or about 150,000 acre-feet per season.

Under provisions of the Raker Act, H.R. 7207, Public Law No. 41, 63rd Congress, Hetch Hetchy water may be used only for municipal purposes, and may be sold only to public agencies. There is excess capacity in the Hetch Hetchy system, over and above present water requirements of areas within its present service area. It is considered probable that the City of San Francisco would supply supplemental water to communities in the Santa Clara Valley having publicly owned water systems. Unit cost of water now delivered by the city to peninsular cities is about \$70 per acre-foot.

In connection with the recent investigation of barriers in the San Francisco Bay system by the Division of Water Resources, consideration was given to the possibility of providing supplemental water to the Livermore and Santa Clara Valleys from the pool of a barrier constructed in the north bay. The fresh water would be pumped and conveyed to the areas of deficiency. The results of the investigation are contained

in a report to the State Water Project Authority by the Division of Water Resources entitled, "Feasibility of Construction by the State of Barriers in the San Francisco Bay System," prepared pursuant to the Abshire-Kelly Salinity Control Barrier Act of 1953, Chapter 1104, Statutes of 1953.

Studies were made of alternative aqueduct routes from three different points of diversion in the barrier pools to supply water to the Livermore and Santa Clara Valleys. Diversion capacities were predicated upon supplying 94,000 acre-feet of water seasonally to Livermore Valley, and 63,000 acre-feet to the Santa Clara Valley. It was assumed that the water would be diverted and conveyed at a uniform rate to terminal reservoirs in each of the service areas, where the supply would be re-regulated and delivered to local agencies for distribution.

One route would extend from Italian Slough in the San Joaquin Delta to Penitencia Creek east of San Jose, a total distance of about 65 miles. This route could be used with any of the barriers located in the north bay, and in many respects is similar to that proposed for the Feather River Project. The water would be diverted from the Feather River Project Aqueduct in the San Joaquin Valley and lifted by pumping to Livermore Valley. The diverted water would be conveyed around the northerly edge of Livermore Valley to a regulating reservoir in Doolan Canyon, about 4 miles northwest of Livermore. Water for the Santa Clara Valley would be conveyed across Livermore Valley from Doolan Canyon Reservoir in a concrete-lined canal, concrete pressure pipe, and tunnel, to a regulating reservoir at the Airpoint site on Arroyo De Los Coches, 2 miles east of Milpitas. Water released from Airpoint Reservoir would be conveyed to a terminal point on Penitencia Creek, about 6 miles northeast of the central district of San Jose.

The second route given consideration in the barrier studies provided for a diversion from the San Joaquin River, about 1 mile west of Antioch. This route would extend for about 76 miles from the intake to a terminus on Penitencia Creek east of San Jose. This aqueduct could be utilized with the barrier located at or below Chipps Island. The diverted water would be lifted by pumping to a tunnel intake located on the west side of Markley Canyon south of Pittsburg. From the tunnel the aqueduct would continue to another tunnel under the hills north of Kirker Pass, thence across Clayton Valley to a tunnel under Lime Ridge, 2 miles south of Concord. From the outlet of this tunnel, the aqueduct would extend southerly along the easterly slope of San Ramon and Amador Valleys, and the northerly slope of Livermore Valley, to a dividing wye, 2 miles east of Parks Air Force Base. Water required in Livermore Valley would be diverted at the wye and delivered to Doolan Canyon Reservoir, discussed under the Italian Slough

diversion. Water for the Santa Clara Valley would be conveyed from the wye south across Livermore Valley to a point 2 miles east of Pleasanton, from where the aqueduct location would be identical with that described for the Italian Slough diversion route.

The third route considered provided for the diversion of water from Suisun Bay, at a point about 1.5 miles east of Avon, and its conveyance to the terminal on Penitencia Creek east of San Jose. The aqueduct would have a total length of about 70 miles. This aqueduct would be utilized with a barrier located at either Dillon Point or Point San Pablo. The water would be conveyed southerly by canal from the point of diversion to a point west of Concord, where it would be lifted by pumping to a canal located on the east side of Ygnacio Valley. This canal would extend southerly to a point about 3 miles east of Walnut Creek, where the water would be lifted to the route described for the Antioch diversion. The remainder of the aqueduct would be identical with that described for the Antioch diversion.

The studies of routes in connection with the barrier investigation were only for the purpose of developing comparative estimates of costs for delivery of water to the Livermore and Santa Clara Valleys. A summary of the estimated capital costs of the three aqueduct routes is presented in the following tabulation. The summary does not include the pro rata share of costs of the barrier which would make the diversion possible.

Italian Slough diversion-----	\$24,888,000
Antioch diversion-----	32,093,000
Avon diversion-----	24,846,000

In connection with the need for supplemental water in the Santa Clara Valley, consideration has also been given to the feasibility of reclaiming and conveying sewage from the City of San Francisco, peninsula cities and communities, and from San Jose, for irrigation use in the Santa Clara Valley. This study was made pursuant to House Resolution 198, adopted by the Assembly on June 1, 1949. It was concluded in this study that, in view of the limited amount of sewage from disposal plants or outfalls from the City of San Francisco which is acceptable as to mineral constituents for reclamation and utilization for irrigation use in the Santa Clara Valley, and in view of the relatively high unit cost that would be involved in the reclamation and utilization of such sewage in the Santa Clara Valley, no further consideration should be given at this time to this source as a possible supplemental water supply for the Santa Clara Valley.

PLANS FOR INITIAL LOCAL DEVELOPMENT

Possible plans for initial local developments of supplemental water supplies for the Santa Clara Valley, together with cost estimates, are described in this section. Design of features of the plans was neces-

sarily of a preliminary nature and primarily for cost estimating purposes. More detailed investigation, which would be required in order to prepare plans and specifications, might result in designs differing in detail from those presented in this bulletin. However, it is believed that such changes would not result in significant modifications in estimated costs.

Capital costs of dams, reservoirs, diversion works, conduits, pumping plants, and appurtenances, included in the considered conservation works and conveyance and distribution systems, were estimated from preliminary designs based largely on data from surveys made during the current investigation. Approximate construction quantities were estimated from these preliminary designs. Unit prices of construction items were determined from recent bid data on projects similar to those in question, or from manufacturers' cost lists, and are considered representative of prices prevailing in the fall of 1954. The estimates of capital cost included costs of rights of way and construction, and interest during one-half of the estimated construction period at 3.5 per cent per annum, plus 10 per cent for engineering and 15 per cent of construction costs for contingencies. Estimates of annual costs included interest on the capital investment at 3.5 per cent, amortization over a 50-year period on a 3.5 per cent sinking fund basis, replacement, operation and maintenance costs, insurance, general expenses, and costs of electrical energy for pumping.

In connection with the ensuing discussion safe yield is defined as the maximum sustained rate of draft from a reservoir that could have been maintained through a critically deficient water supply period to meet a given demand for water for irrigation or other purposes. However, in the case of coordinated operation of surface and underground reservoirs safe yield is defined as the average combined seasonal yield from both surface and underground reservoirs which could be obtained over the base period 1934-35 through 1947-48 in North Santa Clara Valley, and 1932-33 through 1947-48 in South Santa Clara Valley. New water is defined as the yield of water resulting from a new water supply development and method of operation thereof, that would have been wasted without the proposed works.

Because of geographical considerations, possible plans for initial local water development are presented in this section separately for North Santa Clara Valley and South Santa Clara Valley. Locations of the proposed works are shown on Plate 17.

North Santa Clara Valley

It was shown in Chapter III that the present requirement for supplemental water in North Santa Clara Valley is about 44,800 acre-feet per season, and that the ultimate seasonal supplemental requirement probably will be about 262,000 acre-feet. Expansion

and intensification of urban and suburban development has occurred at a rapid rate during the past few years, and it is indicated that such rapid growth with attendant increasing requirement for water, will continue for some time in the future.

Three possible plans were studied in connection with the current investigation to meet requirements for supplemental water in North Santa Clara Valley. The first plan includes construction of new works in North Santa Clara Valley, and their operation in conjunction with existing works. Studies indicated that construction of the new works and their proper operation would result in the full practicable conservation of the remaining water of local streams which presently wastes from the area. This plan is designated the "Northern Valley Project."

The second plan considered for initial construction would provide a dam and reservoir on San Francisco Creek. This project would be operated independently of existing works of the Santa Clara Valley Water Conservation District, and would supply water for urban use in the vicinity of Palo Alto. The cost of water from this project would be relatively expensive. This plan is designated the "Little Francis Project."

The third plan considered for initial construction would provide for a dam and reservoir in Santa Cruz County on Zayante Creek, at a site about 5 miles northeast of Felton, and conveyance of the conserved water westerly to Los Gatos Creek, where it would be available for use in North Santa Clara Valley. The cost of water from this project would be quite expensive. This plan is designated the "Zayante Project."

Each of the three foregoing projects, location of the principal features of which are shown on Plate 17, is a project that could be constructed separately, or simultaneously with one or more of the others. Of the three, only the Northern Valley Project would develop sufficient water to meet the present supplemental requirement of North Santa Clara Valley. However, as was mentioned in Chapter III, the present supplemental requirement totalling 44,800 acre-feet per season, comprises 24,800 acre-feet in the Forebay Zone and 20,000 acre-feet in the Pressure Zone, and water developed to meet these requirements must be allocated accordingly. Such a pattern of distribution would not be possible from works of the Northern Valley Project without construction of additional works and excessive expense. Consequently, in studies for this bulletin it was assumed that the entire yield of water from the existing Lake Elsman, the proposed Little Francis Project, and the proposed Zayante Project, together with water developed by the proposed Coyote Well Field, a part of the Northern Valley Project, would be diverted to the Pressure Zone. By such combined operation, with a prescribed

pattern of distribution, the present supplemental water requirement of North Santa Clara Valley could be met.

Northern Valley Project. In the design of projects for initial local development in the Santa Clara Valley, it was considered desirable to provide works which would be operated in conjunction with existing facilities to give the fullest practicable development of local water supplies. Water conservation works that have been constructed in North Santa Clara Valley were described in Chapter III. Major surface reservoirs exist on Coyote, Almaden, Alamitos, Guadalupe, Arroyo Calero, Los Gatos, and Stevens Creeks. These reservoirs were built and are operated by the Santa Clara Valley Water Conservation District, with the exception of Lake Elsman on Los Gatos Creek, which is owned and operated by the San Jose Water Works. The aggregate storage capacity of the reservoirs is about 150,000 acre-feet. Percolating reservoirs, or spreading ponds, constructed and maintained by the district, have a combined surface area of about 100 acres, and are located on Coyote, Los Alamitos, Los Gatos, San Tomas Aquinas, and Penitencia Creeks. These works, and the yields of water therefrom, were incorporated and utilized in the plans discussed herein.

In essence, the Northern Valley Project would involve the draining of surface reservoirs at the fastest possible rate consistent with percolation capacities of stream channels and percolating ponds downstream. In addition, all of the works would be operated jointly, since maximum retention of surface water would necessitate the transportation of water from streams with high runoff to those with lesser runoff, to provide the required amount of stream percolation capacity for ground water recharge. Yield studies indicated that under this plan, a net total of about 48,300 acre-feet of water per season, of which 8,900 acre-feet is new water, now wasting from North Santa Clara Valley could be conserved. This amount would meet the present supplemental water requirement of 44,800 acre-feet, and in addition would provide surplus water in the amount of about 3,500 acre-feet per season. In the operation of the project, about 14,500 acre-feet per season of the above conserved water would be furnished as a surface supply to lands in the Pressure Zone, thereby reducing draft on the confined aquifers. This amount would include an estimated 5,000 acre-feet per season from Lake Elsman, and 9,500 acre-feet pumped from Coyote Valley which would be furnished to San Jose.

Under the Northern Valley Project, a portion of the water released from reservoirs on Coyote Creek would percolate in the natural channel of Coyote Creek from the Upper Gorge to The Narrows. The remainder of the flow would be diverted and conveyed in the existing Coyote Canal to the existing

diversion works, where the water would be diverted to the east side of the valley for use in the Evergreen area, and to the west side of the valley for spreading in the Alamitos Creek percolating pond and in Guadalupe River below the pond. Los Alamitos Creek and Guadalupe River waters, now percolating in natural channels and in the percolating pond, would be transported westerly in a proposed conduit to Los Gatos Creek. Waters of the latter stream in excess of its channel percolation capacity would be conveyed northward in the existing Vasona Canal and the Vasona Extension Pipe Line.

Operation of the project would result in increased percolation of water in Coyote Valley, making it desirable to operate the ground water basin underlying the valley to enable conservation of additional water. Pumps would be installed in a proposed well field near the northern end of Coyote Valley, and the conserved water would be delivered by pipe line for urban use in San Jose.

Studies were also made of the merits of a project to convey water from Coyote Creek to Penitencia Creek for percolation in the channel of that stream. Such a project would include enlargement of the existing Coyote Extension Canal, use of the recently completed Evergreen Pipe Line and Canal, and construction of a conduit consisting of unlined canal and reinforced-concrete pipe line from Dry Creek to Penitencia Creek. It was indicated that no significant amount of new water would be developed by such a plan, above that which would result from the presently proposed plans of the Santa Clara Valley Water Conservation District to serve surface water in the Evergreen area.

Additional small reservoirs on Permanente, Stevens, Calabazas, Guadalupe, San Antonio, and Madera Creeks, not included in the Northern Valley Project,

could also regulate portions of the runoff on these streams, both for percolation and for gravity service of water to urban areas. However, studies indicated that the small amount of new water developed therefrom would be excessively costly.

Estimates were made of the yield of existing and proposed works under the Northern Valley Project. Based on estimates of runoff during the base period, from 1935-36 through 1947-48, monthly yield studies were made of Anderson and Lexington Reservoirs to determine the yield of the project creditable to these existing reservoirs. After consideration of the results of yield studies, the works subsequently described were chosen for purposes of cost estimates to be presented in this bulletin. A summary of yield studies of Anderson and Lexington Reservoirs, operated in accordance with the Northern Valley Project, is included in Appendix K.

As a method of determining the yield of new water provided by operation of the project, a comparison was made of the estimated seasonal surface outflow from the Forebay Zone during the 13-year base period for base period, present, and proposed conditions. Results of this comparison are presented in Table 40.

Table 40 indicates that under the Northern Valley Project the mean seasonal surface outflow from the Forebay Zone of North Santa Clara Valley would be reduced from about 99,000 acre-feet under base period operation to 42,200 acre-feet, resulting in a total seasonal conservation of about 56,800 acre-feet of water. However, of the total seasonal amount of water conserved 46,300 acre-feet was estimated to be creditable to works under present operation. Therefore, the gross yield of new water from the Northern Valley Project would be 10,500 acre-feet. It was assumed that about 15 per cent of the gross yield of new water from the project would be lost through

TABLE 40
ESTIMATED NEW MEAN SEASONAL YIELD FROM NORTHERN VALLEY PROJECT
(In acre-feet)

Stream	Seasonal surface outflow during 13-year base period, 1935-36 through 1947-48			New yield from proposed works	
	Base period operation*	Present operation	Proposed operation	Gross	Net
Permanente Creek.....	2,300	2,300	2,300	0	0
Stevens Creek.....	3,700	3,700	3,700	0	0
Calabazas Creek.....	1,100	1,100	1,100	0	0
Saratoga Creek.....	4,000	4,000	4,000	0	0
San Tomas Aquinas Creek.....	1,900	1,900	1,900	0	0
Guadalupe River.....	32,600	10,400	8,700	1,700	1,400
Coyote Creek.....	41,400	17,300	8,500	8,800	7,500
Silver and Dry Creeks.....	700	700	700	0	0
Penitencia Creek.....	2,500	2,500	2,500	0	0
Unmeasured east-side streams.....	4,100	4,100	4,100	0	0
Unmeasured west-side streams.....	4,700	4,700	4,700	0	0
TOTALS.....	99,000	52,700	42,200	10,500	8,900

* Prior to construction and operation of Anderson and Lexington Reservoirs, Lake Elsmar, Coyote-Los Alamitos Conduit, Evergreen Conduit, and Vasona Canal Extension.

incidental evaporation and transpiration. Therefore, the net yields, both present and new, would be about 39,400 and 8,900 acre-feet, respectively.

In order to obtain the foregoing yield of new water from the Northern Valley Project, present percolation capacities of natural channels and percolation reservoirs would have to be maintained. These capacities were estimated from records furnished by the Santa Clara Valley Water Conservation District, and are presented in Table 41.

TABLE 41
ESTIMATED PERCOLATION RATES IN STREAMS OF
NORTH SANTA CLARA VALLEY

Stream	Rate of percolation, in second-feet
Penitencia Percolation Pond	15
Coyote Creek	
Between Upper and Lower Gorge	60
In Coyote Percolation Pond	20
Between the pond and The Narrows	15
Alamitos Creek, Guadalupe Creek, and Alamitos Percolation Pond	50
Los Gatos Creek*	85
San Tomas Aquinas Creek	25
Saratoga (Campbell) Creek	20
Calabazas Creek	5
Stevens Creek	15

* Includes percolation in all works on Los Gatos Creek, Vasona Canal, and Upper Page Ditch.

Since, under the Northern Valley Project, releases of water from reservoirs would maintain stream flow for longer periods than at present, the percolation capacities of stream beds were estimated from records of stream flow after the channels had been wetted for long periods of time. During the portions of the year in which Coyote Creek water would be diverted to the Evergreen area for surface irrigation, and percolated in the Alamitos Percolation Pond and the Guadalupe River, water would be released to Coyote Creek from Anderson Reservoir at a rate of about 160 second-feet. Of the release, about 65 second-feet would be diverted into the Coyote Canal for conveyance to the east and west sides of the valley. The remaining 95 second-feet would be released to the natural channel. Under this method of operation, it was estimated that about 60 second-feet would percolate in the reach from the Upper Gorge to the Lower Gorge, 20 second-feet in the Coyote Percolation Pond, and the remaining 15 second-feet in the stream bed between this pond and The Narrows.

Sustained percolation in Coyote Valley, at the rate of 60 second-feet, would be essential to the effectiveness of the plan. However, increasing percolation to the extent proposed would soon fill the ground water reservoir underlying Coyote Valley, thus preventing further influent seepage. Therefore, it would be necessary to operate the ground water basin so as to maintain the required storage space. Under the

Northern Valley Project, ground water levels in Coyote Valley would be lowered during seasons of subnormal water supply in amounts greater than occur under present conditions, so that in seasons of abundant runoff the basin would not completely fill. Thus, the water table would be prevented from rising above levels that produce effluent waters in Fisher Creek. This criterion would assure ample percolation capacity in the valley at all times, and, furthermore, would prevent high ground water levels from adversely affecting crops. It was estimated that under this method of operation about 9,500 acre-feet of water per season, or a constant flow of 13 second-feet, would have to be exported from Coyote Valley, after ground water levels are sufficiently lowered. In the transitional period, during which the water table would be lowered, water would be removed at a rate of about 15 second-feet. In estimating the required export it was assumed that subsurface outflow to South Santa Clara Valley would remain approximately equal to its present value.

To operate the Coyote Valley ground water basin, wells with pumps would be installed in the proposed Coyote Valley Well Field near the north end of the valley. The water pumped from the wells would be conveyed in the proposed Coyote Valley-San Jose Pipe Line for urban use in San Jose. Urban rather than agricultural use of this water would be desirable, since the pumping plants operated more or less continuously for urban use could produce water more economically than if operated to meet a less constant irrigation demand. Furthermore, water pumped from the free ground water zone would relieve the pressure zone pumping draft by an equivalent amount. Distribution problems would be minimized by introducing the imported water into an existing system.

Future irrigation of about 1,430 irrigable acres in Coyote Valley, not now supplied with water, would eventually reduce the amount of the export by approximately 2,900 acre-feet per season. This item was neglected in the present studies, since the over-all conservation of waters would still be effected, so long as the percolation capacity in Coyote Valley was maintained.

Under the foregoing plan of operation, the amplitude of ground water level fluctuations in Coyote Valley would be substantially more than at present. The present range in average water levels is about 60 feet. If the ground water reservoir were operated as proposed, the range in water levels would be about 120 feet, with a maximum average elevation of the water surface of 267 feet, compared to the present value of 284 feet.

It was estimated that the combined percolation capacity of the Alamitos Percolation Pond, and the channel of the Guadalupe River below this pond, is about 50 second-feet. With a maximum diversion of water to them at the rate of 50 second-feet from Coy-



State Division of Highways Photograph
Lexington Dam and Reservoir on Los Gatos Creek

ote Creek, flows from streams naturally tributary to the pond and the Guadalupe River would be diverted in the proposed Calero-Los Gatos Conduit for percolation in Los Gatos Creek. This conduit would extend from Arroyo Calero Creek in a northwesterly direction, and would terminate at the existing Vasona Dam on Los Gatos Creek.

Another feature of the Northern Valley Project would involve the operation of Lexington Reservoir on Los Gatos Creek. This reservoir regulates most of the runoff from Los Gatos Creek in excess of that conserved in Lake Elsmann and diverted from Los Gatos Creek by the San Jose Water Works. Under the project, water would be released from Lexington Reservoir for percolation in Los Gatos Creek, and in major streams north of this creek. The reservoir would be drained as rapidly as possible consistent with maximum, continuous percolation capacities.

The maximum rate of release of water into Los Gatos Creek from Lexington Reservoir would be about 130 second-feet. This would occur when conditions in Los Gatos Creek and in creeks to the north were such as to permit spreading of water at full capacity, with no water available for import through the Calero-Los Gatos Conduit. Approximately 85 second-feet of this quantity would remain in Los Gatos Creek for percolation, or would percolate in the Vasona Canal or the Upper Page Ditch. The remaining 45 second-feet would be diverted from Los Gatos Creek and conveyed northward in the existing Vasona Canal to San Tomas Aquinas Creek, where 25 second-feet would be released for percolation. The remaining 20 second-feet would be conveyed to Saratoga Creek in the Vasona Canal Extension. When available in the Alamitos Creek group, water at rates up to 50 second-feet would be exported to Los Gatos Creek, and the releases of water from Lexington Reservoir would be reduced by an equivalent amount.

General features of proposed dams, reservoirs, conduits and other works of the Northern Valley Project are described in the following subsections.

(1) Coyote Valley Well Field and Coyote Valley-San Jose Pipe Line. The Coyote Valley Well Field would be located in Sections 22, 26, 27, and 35, Township 8 South, Range 2 East, M. D. B. & M., in the northern end of Coyote Valley. It would consist of seven wells and pumps, spaced about one-quarter mile apart. The wells would be in a line adjacent and parallel to Coyote Creek, and would be about 250 feet deep. A deep-well multistage turbine-type pump, with a capacity of 1,000 gallons per minute would be installed at each well. From the wells the water would be conveyed through the Coyote Valley-San Jose Pipe Line a distance of about 12.8 miles to the 12th and Martha Streets pumping plant of the San Jose Water Works. The pipe line would be of reinforced-concrete, with a diameter of 2.5 feet and a capacity of about 15 second-feet. A plan and profile of the proposed con-

duit are shown on Plate 19, entitled "Coyote Valley Well Field and Coyote Valley-San Jose Pipe Line, 1955."

Pertinent data with respect to the various features of the well field and the pipe line, as designed for cost estimating purposes, are presented in Table 42.

TABLE 42
GENERAL FEATURES OF COYOTE VALLEY WELL FIELD
AND COYOTE VALLEY-SAN JOSE PIPE LINE

Coyote Valley Well Field	
Number of wells—	7
Type of pumps—	Deep-well, multistage turbine
Discharging capacity—	1,000 gallons per minute per well
Depth of wells—	250 feet
Drawdown—	25 feet
Minimum static water level elevation—	152 feet
Coyote Valley-San Jose Pipe Line	
Discharging capacity—	15 second feet
Type—	Reinforced-concrete pipe
Length—	12.8 miles
Diameter—	2.5 feet
Average elevation of well field—	270 feet
Elevation of pipe outlet—	100 feet

(2) Calero-Los Gatos Conduit. Water conserved in Calero Reservoir would be diverted from Arroyo Calero in Section 31, Township 8 South, Range 2 East, M. D. B. & M., at a stream bed elevation of about 381 feet. The waters would be conveyed northwesterly in a canal for a distance of about 9 miles to Guadalupe Creek, and then in a pipe line for a distance of about 6 miles. The waters would be discharged to Los Gatos Creek immediately above Vasona Dam. En route, the canal would intercept all or portions of the flows of Alamitos and Guadalupe Creeks.

The canal portion of the conduit, with a capacity of 50 second-feet, would be of trapezoidal section and unlined, with 1:1 side slopes, a bottom width of 4.0 feet, depth of 3.1 feet, and freeboard of 1.4 feet. Its slope would be approximately 3.8 feet per mile, and its velocity about 2.3 feet per second. Main roads and streams along the length of the canal would be crossed with reinforced-concrete pipe culverts. The pipe line portion of the conduit would be of reinforced-concrete pipe with a diameter of 48 inches. The inlet elevation of the pipe line would be about 341 feet, and the outlet elevation about 305 feet.

The diversion structure on Arroyo Calero would be a reinforced-concrete open weir, some 120 feet in length and 3 feet in height above stream bed. It would be divided by 1-foot wide concrete piers into 7-foot flashboard bays. The stream bed elevation at the site of the diversion is about 381 feet. An opening at the left end of the weir would provide entrance to a side channel, leading downstream about 60 feet to the headworks of the canal. The side channel would have a concrete gravity parapet wall of the overpour type, and a 4-foot by 5-foot sluice gate would be provided for sand clearance. The headworks would consist of a concrete headwall across the end of the side channel,

with a 48-inch diameter slide gate and a trashrack. Similar types of structures would be constructed on Alamitos and Guadalupe Creeks.

The diversion structure on Guadalupe Creek would be located about 1.2 miles upstream from the point of crossing of the conduit. The flow thus diverted would be conveyed in a northerly direction in the Guadalupe Creek Intercepting Canal along the right bank of Guadalupe Creek, to join the main conduit from Arroyo Calero at the point of beginning of the pipe line portion of the conduit. The Guadalupe Creek Intercepting Canal, with a capacity of 25 second-feet, would be of trapezoidal section and unlined, with 1:1 side slopes, a bottom width of 2.5 feet, depth of 2.5 feet, and freeboard of 1.0 foot. Its slope would be approximately 4.2 feet per mile, and its velocity about 2.0 feet per second.

Principal features and a plan and profile of the proposed conduit are shown on Plate 20, entitled "Calero-Los Gatos Creek Conduit, 1955." Pertinent data with respect to the various features of the conduit, as designed for cost estimating purposes, are presented in Table 43.

TABLE 43

GENERAL FEATURES OF CALERO-LOS GATOS CONDUIT

Canal, Arroyo Calero to Guadalupe Creek

Capacity—50 second-feet
Type—Trapezoidal, unlined
Length—9.1 miles
Side slopes—1:1
Bottom width—4.0 feet
Depth—3.1 feet
Freeboard—1.4 feet
Slope—3.8 feet per mile
Velocity—2.3 feet per second

Pipe line, Guadalupe Creek to Los Gatos Creek

Capacity—50 second-feet
Type—Reinforced-concrete
Length—4.8 miles
Diameter—4 feet

Guadalupe Creek Intercepting Canal

Capacity—25 second-feet
Type—Trapezoidal, unlined
Length—1.2 miles
Side slopes—1:1
Bottom width—2.5 feet
Depth—2.5 feet
Freeboard—1.0 foot
Slope—4.2 feet per mile
Velocity—2.0 feet per second

Diversion Works

Arroyo Calero—reinforced-concrete open weir with flashboards, 3 feet high and 120 feet long.
Alamitos Creek—reinforced-concrete open weir with flashboards, 5 feet high and 25 feet long.
Guadalupe Creek—reinforced-concrete open weir with flashboards, 12 feet high and 45 feet long.

The capital costs of the Northern Valley Project, on a 3.5 per cent interest basis, and based on prices prevailing in the fall of 1954, were estimated to be \$2,230,000. The corresponding annual costs were estimated to be about \$152,000. The resultant estimated average unit cost of the 8,900 acre-feet of new water is about \$17.00 per acre-foot, excluding costs of pumping the water from the ground water basin. The

estimates of capital and annual costs of the Northern Valley Project are summarized in the following tabulation. Detailed cost estimates are presented in Appendix L.

	<i>Estimated Costs</i>	
	<i>Capital</i>	<i>Annual</i>
Coyote Well Field and Coyote Valley-San Jose Pipe Line—	\$1,204,000	\$90,800
Calero-Los Gatos Conduit—	1,018,000	60,800
Totals	\$2,232,000	\$151,600

Little Francis Project. In Chapter II it was pointed out that the transmission capacity of the aquifers furnishing water to the pressure zone of North Santa Clara Valley is limited, and that the present pumping draft in the pressure zone exceeds the safe yield of these aquifers. This results in decreasing piezometric levels in the pressure zone and the threat of sea-water intrusion. These problems could be eliminated by reduction of the net pumping draft in the pressure zone to an average seasonal amount of about 84,000 acre-feet. To accomplish this, all water demands in the pressure zone, in excess of about 84,000 acre-feet per season would have to be met by a surface water supply imported from the forebay zone or from some other outside source or sources. Under the Little Francis Project, about 3,000 acre-feet of water per season, presently wasting from San Francisquito Creek into San Francisco Bay, would be conserved and furnished to the City of Palo Alto, to enable reduction of the ground water pumping draft on the pressure zone in that area. Such use of water conserved by the project would be a small step toward elimination of the present serious water problems of the pressure zone.

The Little Francis Project would include construction of a dam and reservoir on San Francisquito Creek at a site about 5.4 miles upstream from U. S. Highway 101 in San Mateo County. The conserved waters would be released from the reservoir, and conveyed for a distance of about 1.7 miles in a general easterly direction in a concrete-lined canal, to a water treatment plant to be located northwest of the junction of San Francisquito Creek and Los Trancos Creek. From the treatment plant the water would be pumped easterly in a pipe line for a distance of about 0.7 mile, to a distribution reservoir to be located on a knoll adjacent to the existing right of way of the Hetch Hetchy Aqueduct. From the reservoir the treated water would flow in a pipe line, following a route parallel to the aqueduct right of way for a distance of approximately 1.6 miles, to the intersection of Junipero Serra Boulevard and Page Mill Road, where a proposed connection with the municipal water works of the City of Palo Alto would be located. Principal features of the project are shown on Plate 21, entitled "Little Francis Project, 1955."

Little Francis Dam would be located on San Francisquito Creek about 1.9 miles downstream from the

existing Searsville Lake, in projected Section 17, Township 6 South, Range 3 West, M. D. B. & M., where the stream bed elevation is about 209 feet. The construction of the dam to an elevation of 300 feet, with spillway crest elevation of 290 feet, would create a reservoir having a storage capacity of about 7,300 acre-feet. The estimated mean seasonal runoff from the drainage area of 28.1 square miles above the dam site is about 12,300 acre-feet. The estimated safe seasonal yield of the reservoir would be about 3,000 acre-feet. A summary of the yield study is included in Appendix K.

Topography of Little Francis dam and reservoir sites was obtained from the Palo Alto Quadrangle of the United States Geological Survey, at a scale of 1:24,000 with contour interval of 20 feet. Storage capacities of the reservoir at various stages of water surface elevation are given in Table 44.

TABLE 44
AREAS AND CAPACITIES OF LITTLE FRANCIS
RESERVOIR

Depth of water at dam, in feet	Water surface elevation, USGS datum, in feet	Water surface area, in acres	Storage capacity, in acre-feet
0-----	209	0	0
21-----	230	12	100
41-----	250	58	750
61-----	270	164	3,000
81-----	290	284	7,350
91-----	300	367	11,850

Based upon preliminary geological reconnaissance, the Little Francis dam site is considered suitable for an earthfill dam of any height up to about 100 feet. Foundation rock at the site consists of the Chico and possibly Purisima formations, which are made up of brown sandstone and conglomerate, yellow siltstone, and terrace sands and gravels. The colors of the rocks are brown and yellow, and they are massive with varying hardness. The grain size varies from fine to cobbles. There are abundant deeply weathered joints, with probable faults normal to the dam axis. Several small shears were visible in the channel section. Some grouting would be required.

Stripping under the impervious section of the dam would require the removal of about 5 feet of soil, and 15 feet of weathered bedrock on the right abutment. Stripping on the left abutment would require the removal of about 2 feet of soil and 10 to 25 feet of weathered materials. Stripping from the channel section would require the removal of about 10 feet of silt, cobbles, and fractured bedrock.

There are several available sources of material suitable for the impervious section of the dam. Weathered, clayey material of the Purisima formation is available at the dam site. Terrace silts and soils are available about 1 mile downstream, and additional

clays and silts are available about 2.5 miles upstream from Searsville Lake. Terrace sands and gravels suitable for the pervious section of the dam are available within 1 mile upstream and downstream from the site, and material salvaged from excavation could also be used. Riprap could be quarried within about 3 miles from the site.

The reservoir area consists of a narrow, irregular valley. The area north of the San Francisquito Creek is covered with light brush, with a few trees. The area south of the creek is covered with a dense growth of brush and timber. Improvements that would be inundated by a reservoir of the chosen capacity at the Little Francis site consist of about 0.25 mile of Sandhill Road and about 0.15 mile of Whiskey Hill Road, 9 homes, 1 ranch, and about 1.9 miles of 12-inch diameter cast iron pipe line extending from Searsville Lake to Stanford University. The portions of the Sandhill and Whiskey Hill Roads which would be inundated are in the upper end of the reservoir area, and could be relocated by raising the grade of the existing roads.

As designed for cost estimating purposes, the dam would be an earthfill structure, 81 feet in height from stream bed to spillway lip, and would have a crest elevation of 300 feet. It would have a crest length of about 1,365 feet, a crest width of 30 feet, and 2.5:1 upstream and downstream slopes. The central impervious earthfill section would have a top width of 10 feet, and 1:1 upstream and downstream slopes. The upstream face of the dam would be protected with a 3-foot layer of riprap. The dam would have an estimated volume of 431,000 cubic yards.

The concrete spillway would be of the chute type with an ogee weir, and would be located through a saddle on the left abutment. The maximum depth of water above the spillway lip would be 6 feet, and an additional 4 feet of freeboard would be provided. The spillway would have a discharging capacity of 9,000 second-feet, based on an estimated flood runoff of 320 second-feet per square mile of watershed above the dam. The spillway would have a crest length of 175 feet, and would discharge into a concrete-lined chute about 2,000 feet in length, with a stilling basin at the lower end.

The outlet works would consist of a 36-inch diameter steel pipe, placed in a trench excavated beneath the dam and encased in concrete. Releases of water from the reservoir would be controlled at the upstream end of the pipe by a 36-inch diameter slide gate, hydraulically operated from the right abutment of the dam. The outlet would be controlled at the downstream end by a 30-inch diameter hollow jet valve, and the water would be released into a stilling basin, from which it would either enter the conveyance canal to the treatment plant, or spill through a wasteway into the San Francisquito Creek channel. The stilling basin would be a reinforced-concrete

structure, 12 feet in width, 50 feet in length, and 10 feet in height. The elevation of the floor of the stilling basin would be about 215 feet. Flow from the stilling basin to the canal would be controlled by a 2-foot by 2-foot slide headgate set in the headwall. Excess water in the stilling basin would spill to San Francisco Creek over a weir 20 feet in length, with a crest elevation of about 220 feet.

The canal to the treatment plant would have a capacity of 10 second-feet, and would extend from the stilling basin in an easterly direction for a distance of approximately 8,800 feet, to a point about 1.5 miles southwest of Stanford University, and northwest of the intersection of Los Trancos and San Francisco Creek, west of Alpine Road. The canal would be shotcrete-lined, and of trapezoidal section, with 1:1 side slopes, bottom width of 2 feet, depth of 1.5 feet, and freeboard of 0.5 foot. Its slope would be approximately 3.2 feet per mile, and the velocity of flow would be about 1.9 feet per second. The canal would follow the south bank of San Francisco Creek for about 0.25 mile, then would cross the creek at a point about 1,000 feet upstream from the spillway stilling basin, and would continue in a northeasterly direction to terminate at the treatment plant at an elevation of about 212 feet. Two 20-inch diameter welded steel siphons would be required to convey the flow across the creek and beneath the spillway channel.

Water entering the treatment plant would pass through flash mixing tanks, where lime and soda ash would be added. Alum would be added as required to promote flocculation of suspended matter. After thorough mixing, the water would be conveyed through settling basins, where the sludge would be settled and mechanically removed. After leaving the settling basins the water would pass through rapid sand filters, and would be chlorinated before being pumped to the distribution reservoir. The treatment plant would include 2 flash mixing tanks with a 45-minute mixing period; 4 settling basins with a 4-hour detention period; 4 filter units of 2 filters each, with a total area of 160 square feet; pipe gallery; operating gallery; raw and waste water channels; administrative offices and laboratory; chemical building to house chlorine cylinders, scales, a chlorinating machine, chemical feeder, and garage; wash water tank; and other necessary appurtenances.

A pumping plant would be located adjacent to the treatment plant, and would consist of an enclosed reinforced-concrete structure, housing 3 electrically driven and 1 standby gasoline driven multistage centrifugal pumping units. Each of the electrically driven units would have a discharging capacity of 2.7 second-feet, and would be driven by a 60-horsepower motor. The standby unit would have a capacity of 7.8 second-feet, and would be driven by a 150-horsepower

gasoline engine. The pumps would operate at a maximum pressure head of 138 feet, pumping from a water surface elevation at the intake of 203 feet to a maximum water surface elevation at the distribution reservoir of 333 feet.

The pump discharge line would be about 3,600 feet in length, and would extend from the pumping plant in an easterly direction to a summit adjacent to the right of way of the Hetch Hetchy Aqueduct, where a distribution reservoir would be located. The pipe line would consist of a buried, 20-inch diameter, welded steel pipe, and would have a discharging capacity of 7.8 second-feet.

The distribution reservoir would be of the paved cavity type, with a reinforced-concrete roof. The reservoir, with floor elevation of 321 feet, would have a floor diameter of 150 feet and 1.5:1 side slopes. It would have a storage capacity of 2,000,000 gallons, with a maximum water depth of 12 feet. At least 1.5 feet of earth cover would be maintained on the roof to keep the treated water cool.

The conduit to the connection with the water distribution system of the City of Palo Alto would consist of buried, 22-inch diameter, welded steel pipe. It would follow a route adjacent and parallel to the existing right of way of the Hetch Hetchy Aqueduct. The pipe line would be about 8,500 feet in length, and would extend from the distribution reservoir to the intersection of Junipero Serra Boulevard and Page Mill Road. The maximum water surface elevation at the inlet would be 333 feet, which would result in a pressure head elevation at the outlet of 275 feet with the design rate of flow of 15 second-feet. The invert elevation of the pipe at the outlet would be about 160 feet.

Pertinent data with respect to the general features of the Little Francis Project, as designed for cost estimating purposes, are presented in Table 45.

The capital cost of the Little Francis Project, on a 3.5 per cent interest basis, and based on prices prevailing in the fall of 1954, was estimated to be about \$3,380,000. Corresponding annual costs were estimated to be about \$220,000. The resultant estimated average unit cost of the 3,000 acre-feet per season of new water was about \$75.00 per acre-foot, delivered to the distribution system of the City of Palo Alto. The estimates of capital and annual costs are summarized in the following tabulation. Detailed cost estimates are presented in Appendix L.

	<i>Estimated Costs</i>	
	<i>Capital</i>	<i>Annual</i>
Little Francis Dam and Reservoir	\$2,202,000	\$104,000
Conduit to treatment plant	53,000	3,000
Treatment and pumping plants	778,000	94,000
Pump line, distribution reservoir, and pipe line to city system	344,000	21,000
Totals	\$3,377,000	\$222,000

TABLE 45
GENERAL FEATURES OF LITTLE FRANCIS PROJECT

Little Francis Dam

Type—earthfill
Crest elevation—300 feet
Crest length—1,365 feet
Crest width—30 feet
Height, spillway lip above stream bed—81 feet
Side slopes—2.5:1, upstream and downstream
Freeboard, above spillway lip—10 feet
Elevation of streambed—209 feet
Volume of fill—412,900 cubic yards

Little Francis Reservoir

Surface area at spillway lip—284 acres
Storage capacity at spillway lip—7,300 acre-feet
Drainage area, San Francisquito Creek—28.1 square miles
Estimated mean seasonal runoff, San Francisquito Creek—9,700 acre-feet
Estimated safe seasonal yield—3,000 acre-feet
Type of spillway—Concrete-lined chute around left abutment
Spillway discharge capacity—9,000 second-feet
Type of outlet—36-inch diameter steel pipe beneath dam

Conduits

	Little Francis Dam to treatment plant	Treatment plant to distribution reservoir	Distribution reservoir to City of Palo Alto system
Type.....	Concrete-lined canal	20-inch diame- ter welded steel pipe	22-inch diame- ter welded steel pipe
Length, in miles.....	1.7	0.7	1.6
Capacity, in second-feet.....	10	7.8	15
Inlet elevation, in feet.....	218	203	321
Outlet elevation in feet.....	212	333	160

Treatment plant

Flash mixing tanks—2 tanks, with a 45-minute mixing period
Sedimentation basins—4 basins, with a 4-hour detention period
Rapid sand filters—4 units of 2 filters each, with a surface area of 160 square feet per filter.

Pumping plant

Pumps—3 centrifugal, with capacity of 1.7 million gallons daily each; one centrifugal, with capacity of 5 million gallons daily
Maximum pumping pressure head—138 feet
Average water surface elevation at intake—203 feet
Installed pumping capacity—10 million gallons daily
Motors—3 electric units, squirrel-cage, open type, 60 horsepower; one standby unit, gasoline, 150 horsepower

Distribution reservoir

Type—Concrete paved cavity, with reinforced-concrete roof with 1.5 feet of earth cover
Storage capacity—2 million gallons
Dimensions—150-foot diameter circular base, 1.5:1 side slopes, 12-foot maximum water depth

Zayante Project. The Zayante Project would include the construction of a dam and reservoir on Zayante Creek in Santa Cruz County. Water conserved in the reservoir would be pumped and conveyed by pipe line in a general northeasterly direction, through existing abandoned railroad tunnels through the Santa Cruz Range, and would discharge on the easterly slopes of the range into Los Gatos Creek at Wrights, about 3 miles upstream from Lexington Reservoir. From Los Gatos Creek the water would be available for use in the Santa Clara Valley, either by direct diversion into facilities of the San Jose Water Works Company, or by storage in Lexington Reservoir for release to downstream percolation

works. Principal features of the project are shown on Plate 22, entitled "Zayante Project, 1955."

Zayante Dam would be located on Zayante Creek about 5 miles upstream from its confluence with the San Lorenzo River, in the southeast quarter of Section 36, Township 9 South, Range 2 West, M. D. B. & M., where the stream bed elevation is about 476 feet. Construction of the dam to an elevation of 616 feet, with a spillway crest elevation of 603 feet, would create a reservoir having a storage capacity of about 6,900 acre-feet. The estimated mean seasonal runoff from the drainage area of 9.5 square miles above the dam site is about 9,000 acre-feet. The estimated safe seasonal yield of the reservoir would be about 4,000 acre-feet.

A plane table topographic survey of the Zayante dam site was made by the Division of Water Resources in 1951, at a scale of 1 inch to 200 feet, with 10-foot contour interval. Reservoir topography was obtained in 1951 by photogrammetric methods, at a scale of 1 inch to 500 feet, with 20-foot contour interval. Areas and capacities of Zayante Reservoir at various stages of water surface elevation are given in Table 46.

TABLE 46
AREAS AND CAPACITIES OF ZAYANTE RESERVOIR

Depth of water at dam, in feet	Water surface elevation, USGS datum, in feet	Water surface area, in acres	Storage capacity, in acre-feet
0.....	476	0	0
24.....	500	8	100
44.....	520	21	390
64.....	540	40	990
84.....	560	70	2,090
104.....	580	108	3,880
127.....	603	153	6,900
144.....	620	191	9,800
164.....	640	238	14,100
184.....	660	292	19,400
204.....	680	350	25,800
224.....	700	413	33,400

The Zayante dam site lies in the Vaqueros formation of Miocene age. The strata consist of fine-grained sandstone and siltstones, with intercalated layers of tan shales having a thickness of as much as 8 inches. Sandstone exposed on the channel edge is moist and shows a strong tendency to spall. There are many tight shears throughout the area. Joints are numerous near the surface, but probably tighter and more widely spaced with depth. Attitudes of the bedding are generally consistent, with the strike parallel to the stream course and the dip into the right abutment.

Stripping for the foundation of an earthfill type of dam at this site should not exceed 6 feet of overburden and 4 feet of fractured rock for the right abutment, and 5 feet of overburden and 2 feet of rock for the left abutment. The stated depths are esti-

mated normal to the surface. Stripping in the channel section would consist of about 4 feet of mixed sand and gravel. It might be, however, that the possible presence of concealed landslide detritus would materially increase the stripping estimates. Moderate grouting of joints and bedding planes would probably be required.

An estimated 1,500,000 cubic yards of earth suitable for use in an impervious embankment is located near Olympia, about 2 miles downstream from the site. Material suitable for riprap would have to be hauled from a distance of at least 4 miles.

Zayante Dam, as designed for cost estimating purposes, would consist of an earth and rockfill structure, with a crest length of 470 feet, a crest width of 28 feet, and upstream and downstream slopes of 2.5:1. The central impervious core would have a top width of 10 feet, and 0.8:1 slopes. The upstream slope of the dam would be faced with a 3-foot layer of riprap. The dam would have an estimated volume of fill of 433,800 cubic yards.

The concrete-lined spillway would be of the ogee weir type, located across the right abutment of the dam, and discharging through a chute into Zayante Creek about 400 feet below the dam. It would have a discharging capacity of 8,900 second-feet, required for an estimated maximum flood flow of about 950 second-feet per square mile of drainage area. The maximum depth of water above the spillway lip would be 8 feet, and an additional 5 feet of freeboard would be provided. The outlet works would consist of a 36-inch diameter steel pipe, placed in a trench excavated beneath the dam and encased in concrete. Releases of water from the reservoir would be controlled by means of gates in an inclined structure on the slope of the left abutment upstream from the dam. This structure would consist of a sloping 48-inch diameter steel pipe encased in concrete, and would be provided with four 18-inch diameter gate valves, hydraulically operated from a control house on the top of the structure.

The reservoir area is generally rugged, and is covered with small brush and some second-growth redwood, and oak and madrone, which would have to be removed. The land has little agricultural value. Improvements in the reservoir area consist of 5 cottages, with garages and water systems, that are occupied throughout the year, and 14 summer residences and weekend cabins. Public utilities which would require relocation consist of about 3 miles of county roads, power lines, and telephone lines.

The pumping plant would be located on the left abutment near the downstream toe of the dam. The plant would consist of an enclosed reinforced-concrete structure, housing 3 electrically driven multistage, centrifugal pumping units. Each of the units would comprise a 10-inch diameter pump, with discharging capacity of 6.7 second-feet, driven by a 450-horse-

power motor. The pumps would operate at a maximum head of about 470 feet, pumping from an estimated minimum water surface elevation in the reservoir of 500 feet, to a discharge elevation of 895 feet near Los Gatos Creek. The pump intakes would connect directly to the 36-inch diameter reservoir outlet pipe, and would discharge into a 30-inch diameter steel conduit in a manifold arrangement. A 10-inch diameter by-pass would be installed at the end of this system. Three 10-inch diameter check valves would be placed on the discharge pipes of the pumping units, while three 10-inch diameter gate valves would be used on the intake side. The by-pass would be provided with a 10-inch diameter gate valve.

The pipe line to Los Gatos Creek would consist of a 30-inch diameter steel pipe, about 6.4 miles in length, and would utilize a portion of the former road bed of the Southern Pacific Railroad between Santa Cruz and Los Gatos, which was abandoned in March of 1941. From the pumping plant, the pipe line would extend up the left abutment of the dam for a distance of 500 feet to the railroad bed, located at an elevation of 636 feet. The pipe line would then follow the alignment and grade of the road bed in a northeasterly direction, terminating about 0.1 mile southwest of the station of Wright on Los Gatos Creek, at an elevation of about 895 feet. Three railroad tunnels would be utilized en route. It was estimated that 2,400 linear feet of excavation would be necessary to clear the tunnel portals.

Pertinent data with respect to general features of the Zayante Project, as designed for cost estimating purposes, are presented in Table 47.

TABLE 47
GENERAL FEATURES OF ZAYANTE PROJECT

Earthfill Dam

Crest elevation—616 feet
Crest length—470 feet
Crest width—28 feet
Height, spillway lip above stream bed—127 feet
Side slopes—2.5:1 upstream and downstream
Freeboard, above spillway lip—13 feet
Elevation of stream bed—476 feet
Volume of fill—433,800 cubic yards

Reservoir

Surface area at spillway lip—153 acres
Storage capacity at spillway lip—6,900 acre-feet
Drainage area—9.5 square miles
Estimated mean seasonal runoff—9,000 acre-feet
Estimated safe seasonal yield—4,000 acre-feet
Type of spillway—Ogee weir, concrete-lined chute
Spillway discharging capacity—8,900 second-feet
Type of outlet—36-inch diameter steel pipe beneath dam

Pumping Plant

Pumps—3 each, multistage, centrifugal, 6.7 second-foot capacity
Minimum water surface elevation in reservoir—500 feet
Discharge elevation—895 feet
Maximum pumping head—472 feet
Installed pumping capacity—20 second-feet
Motors—3 each, open type, 450 horsepower

Conduit

Type—welded steel pipe
Length—6.4 miles
Diameter—30-inch
Discharging capacity—20 second-feet

The capital cost of the Zayante Project, on a 3.5 per cent interest basis, and based on prices prevailing in the fall of 1954, was estimated to be about \$2,660,000. Corresponding annual costs were estimated to be about \$180,000. The resultant estimated average unit cost of the 4,000 acre-feet of water per season by the Zayante Project is, therefore, about \$45.00 per acre-foot. The estimates of capital and annual costs are summarized in the following tabulation. Detailed cost estimates are presented in Appendix L.

	<i>Estimated Costs</i>	
	<i>Capital</i>	<i>Annual</i>
Dam and reservoir-----	\$1,299,400	\$63,000
Pumping plant-----	120,200	47,300
Pipe line-----	1,237,600	69,100
Totals -----	\$2,657,200	\$179,400

Discussion of Plans for Initial Local Development for North Santa Clara Valley

In the foregoing sections, three plans were presented which would provide new water for use in North Santa Clara Valley. The Northern Valley Project would involve construction of works, which, when operated in conjunction with existing works, would provide a safe yield of about 8,900 acre-feet of new water per season, at a cost of about \$17.00 per acre-foot, excluding costs of pumping the water from the ground water basin. The second plan, the Little Francis Project, would involve construction of a dam and reservoir on San Francisquito Creek, and treatment and conveyance of the conserved water for use in the City of Palo Alto. The project would provide a safe yield of about 3,000 acre-feet of water each season, at a cost of about \$75.00 per acre-foot. The third plan, the Zayante Project, would involve construction of a dam and reservoir on Zayante Creek in Santa Cruz County, and conveyance of the conserved water in pipe line and existing tunnels to the Santa Clara Valley. The project would provide a safe seasonal yield of about 4,000 acre-feet, at a cost of about \$45.00 per acre-foot, excluding costs of distribution or cost of pumping from the ground water basin if the water were diverted into existing percolation works.

The three projects would provide a total of about 15,900 acre-feet of new water per season, at a weighted average unit cost of \$35.00 per acre-foot. This cost is considerably above the range of recently estimated costs of water from the Feather River Project, and suggests that the continued additional development of local water supplies in the Santa Clara Valley is uneconomic, and that consideration should be given to means of obtaining future supplemental water supplies from an outside source or sources.

South Santa Clara Valley

It was shown in Chapter III that the estimated present requirement for supplemental water in South Santa Clara Valley is about 7,000 acre-feet per season, and that the ultimate seasonal supplemental requirement probably will be about 21,000 acre-feet.

The results of surveys and studies show that the probable ultimate requirement for supplemental water in South Santa Clara Valley could be met by the construction and operation of a reservoir of 34,000 acre-foot storage capacity on Uvas Creek, a diversion conduit of 50 second-foot capacity from Uvas Creek to Llagas Creek, and percolation ponds on Llagas Creek from U. S. Highway 101 about 4.2 miles downstream, and the utilization of water yielded from Chesbro Reservoir, now under construction on Llagas Creek by the South Santa Clara Valley Water Conservation District. The estimated safe yield of new water from this system of works would be about 22,000 acre-feet. Of this new yield, an average of about 16,300 acre-feet of water per season would be made available from the proposed reservoir on Uvas Creek, and 5,700 acre-feet per season from Chesbro Reservoir on Llagas Creek. These plans are described in some detail in the following section.

The South Santa Clara Valley Water Conservation District is planning construction of a dam and reservoir on Uvas Creek with a storage capacity of 10,000 acre-feet. This reservoir, if operated in conjunction with Chesbro Reservoir, and with a percolation capacity of 50 second-feet in Llagas Creek, would provide new water in the amount of about 9,900 acre-feet per season. The combined new seasonal yield of Chesbro Reservoir and this reservoir on Uvas Creek would be about 15,600 acre-feet.

Uvas and Llagas Creeks Project. This project would include the construction of a dam and reservoir on Uvas Creek, a conduit to convey a portion of the conserved water to Llagas Creek, and a number of small check dams on Llagas Creek to increase percolation. The project would be operated in conjunction with Chesbro Reservoir on Llagas Creek. Water conserved by the project would prevent progressive and permanent lowering of ground water levels in South Santa Clara Valley, and would provide for the ultimate supplemental water requirement. Principal features of the project are shown on Plate 23, entitled "Uvas and Llagas Creeks Project, 1955."

Uvas Dam would be a rock and earthfill structure with chute spillway, located on Uvas Creek in Section 18, Township 10 South, Range 3 East, M. D. B. & M., at the site of the Gilroy Water Works Diversion Dam, some 7 miles northwest of the City of Gilroy. The stream bed elevation at the site is 392 feet. Flood waters of Uvas Creek conserved by Uvas Reservoir would be released at an elevation of approximately



*Chesbro Dam on Llagas
Creek, May 26, 1955*



*Gilroy Water Works Dam
at Uvas Dam Site
on Uvas Creek*

425 feet, and transported to Llagas Creek in a conduit, consisting of 1.8 miles of reinforced-concrete pipe and 1.5 miles of unlined canal, which would terminate at an elevation of about 350 feet on Llagas Creek. The diversion of Uvas Creek water would be necessary, since sufficient capacity for its percolation is not available in the Carnadero and Uvas Creek channels. The diverted water would flow to percolation ponds to be located on Llagas Creek between U. S. Highway 101 and Rucker Avenue.

A topographic survey of the Uvas dam site was made by Blackie and Wood, Civil Engineers, in September, 1952, at a scale of 1 inch to 50 feet, with 10-foot contour intervals. A map of the reservoir area was presented in the Blackie and Wood "Report to the Honorable Board of Directors South Santa Clara Valley Water Conservation District on Llagas Creek and Uvas Creek Well Replenishment Project," Project Report No. 14, and has a scale of 1 inch to 100 feet, with 20-foot contour intervals. Storage capacities of Uvas Reservoir at various stages of water surface elevation, derived from this map, are given in Table 48.

TABLE 48
AREAS AND CAPACITIES OF UVAS RESERVOIR

Depth of water at dam, in feet	Water surface elevation, USGS datum, in feet	Water surface area, in acres	Storage capacity, in acre-feet
0-----	392	0	0
28-----	420	50	100
48-----	440	105	2,000
68-----	460	180	5,400
88-----	480	270	10,000
108-----	500	390	17,500
128-----	520	530	26,500
142-----	534	630	34,400
148-----	540	680	38,200
168-----	560	850	54,000

Based upon preliminary geological reconnaissance, the Uvas dam site is considered suitable for a rock or earthfill dam with a maximum height of about 200 feet. Bedrock at the site consists of a gray to greenish, very fine-grained to aphanitic, slightly metamorphosed sandstone, with occasional associated shales, and containing locally a few small lenses of chert. It is generally tight, although finely jointed where weathering extends to a depth of several inches below the surface. Some blocky-type jointing occurs, with up to 2 inches of separation on the surface being noted in some places. However, these joints should tighten a short distance below the surface. No shears or faults of significance were observed. On the right abutment, in addition to the above type of rock, some medium-grained, relatively unmetamorphosed, red to tan sandstone was noted in talus slopes, but was not found outcropping. A small pocket of purple, strongly weathered, and metamorphosed (schistose)

volcanic rock was noted near the axis at the base of the right abutment.

No serpentine was found, even in drill holes recently drilled for the South Santa Clara Valley Water Conservation District, except as stream float. The rock is apparently a part of the Franciscan series of Jurassic Age. Some small-scale landsliding and mantle creep occur on the right abutment. This slope has apparently been subjected in the past to slow downward movement of overburden.

Stripping under the impervious section of the dam would require the removal of about 9 feet of soil and 3 feet of weathered rock on the right abutment. Stripping on the left abutment would require the removal of about 3 feet of rock. Stripping from the channel section would require the removal of about 37 feet of earth and gravel.

A suitable location for a chute spillway exists in the left abutment ridge, at an elevation about 200 feet above stream level. The height of dam selected, however, would necessitate a spillway cut of about 60 feet, but the ridge is thin at this point. The excavation would be almost entirely in sandstone, and this material could be salvaged in its entirety for use in construction of the dam.

There is apparently sufficient soil material for impervious fill within one-half mile of the dam site. A considerable amount was located downstream. Some earth would also be obtained as salvage from stripping of the broad terrace on the right side of the channel. Another good source of impervious material appears to be on the upstream base of the right abutment.

Aggregates, consisting of typical Franciscan gravels mixed with sand, and including meta-sediments, volcanics, cherts, and some serpentine fragments, could be recovered from the stream channel locally. Gravels at the axis are thin, and confined to a narrow zone of active channel, but much more extensive deposits were noted upstream within a distance of 1 mile. The sandstone bedrock would supply adequate quantities of rockfill, and possibly riprap. Much of this material could be salvaged from stripping of the abutments, and from excavation in the spillway cut.

The reservoir would inundate approximately 700 acres of land, which would require clearing of a sparse growth of trees and brush. About 4.5 miles of county road would require relocation. Twelve residences and a number of barns and buildings would also be inundated.

As a result of yield studies, geologic reconnaissance, and preliminary economic analysis, an earthfill dam, 142 feet in height from stream bed to spillway lip, and with a crest elevation of 549 feet, was selected to illustrate estimates of costs of the Uvas Dam and Reservoir. The dam would have a crest length of about 1,255 feet and a crest width of 30 feet, and 2.5:1 upstream and downstream slopes. The central imper-

vious core would have a top width of 10 feet, and 0.75:1 slopes. The outer pervious zones would consist of stream bed gravels and material salvaged from stripping and excavation. The volume of fill would be an estimated 2,165,000 cubic yards.

The spillway would be of the chute type, located on the left abutment. The maximum depth of water above the spillway lip would be 10 feet, and an additional 5 feet of freeboard would be provided. The spillway would have a discharging capacity of 20,000 second-feet, required for an assumed maximum flood flow of 660 second-feet per square mile of drainage area. The spillway would discharge into a draw which joins Uvas Creek downstream from the toe of the dam.

The outlet works would consist of a 36-inch diameter steel pipe, placed in a trench excavated in rock beneath the left abutment of the dam and encased in concrete. Releases of water from the reservoir would be controlled at the upstream end of the pipe by a 36-inch diameter hydraulically controlled gate. The outlet would be controlled at the downstream end of the pipe by a 30-inch diameter hollow jet valve. The water would be released into a stilling basin, from which it would either enter the Uvas-Llagas Conduit, to be conveyed to Llagas Creek for percolation, or would spill through a wasteway into the Uvas Creek channel. The stilling basin would be a reinforced-concrete structure, 12 feet in width, 60 feet in length, and 12 feet in height. The elevation of the bottom of the stilling basin would be about 419 feet. Flow from the stilling basin to the conduit would be controlled by a 5-foot by 4-foot slide gate set in the head-wall. Excess water in the stilling basin, as well as water released at the rate of 10 second-feet for percolation in Uvas Creek, would discharge over a weir to return to the channel downstream from the dam. The length of the weir would be 20 feet, and its crest elevation 425 feet.

The Uvas-Llagas Conduit, with a capacity of 50 second-feet, would consist of about 1.8 miles of 48-inch diameter reinforced-concrete pipe and 1.5 miles of unlined canal. The pipe line, beginning at the dam outlet stilling basin, would follow the left bank of Uvas Creek for a distance of about 1.2 miles. It would then swing northerly a distance of about 0.5 mile, to discharge into the unlined canal at Sycamore Road, on the saddle between Uvas and Llagas Creeks. The water would be conveyed northerly in the canal to a concrete-lined chute to Llagas Creek, located about 0.5 miles downstream from the Machado School. Here the water would drop 50 feet to the stream bed, where the elevation is about 350 feet. The unlined canal would be of trapezoidal section, with 1:1 side slopes, bottom width of 5 feet, depth of 2.5 feet, and freeboard of 1 foot. The slope of the canal would be about 5.9 feet per mile, and the maximum velocity of water in the canal would be 2.7 feet per second.

The chute would be about 200 feet in length, including a stilling basin 50 feet in length. The diverted water would flow in the natural channel of Llagas Creek to percolation ponds extending from U. S. Highway 101 about 4.2 miles downstream.

The present capacity for percolation of water in Llagas Creek was estimated from measurements made during the current investigation and from prior studies. The estimated percolation rate amounts to about 30 second-feet over the Forebay Zone from Llagas Avenue to Rucker Avenue. Other data indicate that the present rate of percolation from Llagas Creek is susceptible of increase to about 50 second-feet, by the construction of low dams in the channel to increase the area of wetted stream bed. About 50 acres of stream bed would be required to obtain this percolation capacity.

Under the project, 23 low sausage-type dams would be constructed at strategic locations on Llagas Creek,

TABLE 49
GENERAL FEATURES OF UVAS AND LLAGAS
CREEKS PROJECT

Uvas Dam—earthfill

Crest elevation—549 feet
Spillway elevation—534 feet
Crest length—1,255 feet
Crest width—30 feet
Height, spillway lip above stream bed—142 feet
Side slopes—2.5:1 upstream and downstream
Freeboard, above spillway lip—15 feet
Elevation of stream bed—392 feet
Volume of fill—2,250,000 cubic yards

Uvas Reservoir

Surface area at spillway lip—630 acres
Storage capacity at spillway lip—34,000 acre-feet
Drainage area—30.3 square miles
Estimated mean seasonal runoff—26,500 acre-feet
Estimated seasonal new yield—16,300 acre-feet
Type of spillway—lined chute with ogee weir control
Spillway discharging capacity—20,000 second-feet
Type of outlet—36-inch diameter steel pipe beneath dam

Uvas-Llagas Conduit

Uvas Dam to Sycamore Road	Sycamore Road to Llagas Creek
Type—reinforced-concrete pipe line	Type—unlined canal
Length—1.8 miles	Length—1.5 miles
Diameter—48 inches	Side slope—1:1 in cut
Velocity—4.0 feet per second	1.5:1 in fill
Capacity—50 second-feet	Bottom width—5.0 feet
	Depth—2.5 feet
	Freeboard—1.0 foot
	Slope—5.9 feet per mile
	Velocity—2.7 feet per second
	Capacity—50 second-feet

Llagas Creek Percolation Ponds

Total area—50 acres
Maximum percolation capacity—50 second-feet
Sausage dams
Type—rockfilled and covered with chain link mesh
Number—23
Average crest length—100 feet
Height above stream bed—3.0 feet
Total volume of fill—2,800 cubic yards

between Llagas and Rucker Avenues. The dams would be constructed to a height of 3 feet, and their average crest length would be about 100 feet. The dams would be of rock fill and covered with chain link mesh. They would be provided with rockfilled aprons, 10 feet or more in length, with a rolled rockfilled "sausage" section at the downstream end of the aprons. The aprons would be located immediately below the dams.

Under the method of operation proposed for the Uvas and Llagas Creeks Project, releases of water would be made from Uvas Creek Reservoir to permit maximum percolation in Uvas Creek at a rate of 10 second-feet. Additional releases of water would be made up to a rate of 50 second-feet, providing such releases could be diverted to and percolated in the Llagas Creek percolation ponds. The availability of percolation capacity in Llagas Creek would depend upon the rate of release of stored water from Chesbro Reservoir.

Pertinent data with respect to general features of the Uvas and Llagas Creeks Project, as designed for cost estimating purposes, are presented in Table 49.

The capital cost of the Uvas and Llagas Creeks Project, on a 3.5 percent interest basis and with prices prevailing in the fall of 1954, was estimated to be about \$3,920,000. Corresponding annual costs were estimated to be about \$194,000. The resultant estimated average unit cost of the 16,300 acre-feet per season of new water from the Uvas and Llagas Creeks Project was about \$11.90 per acre-foot. The estimates of capital and annual costs are summarized in the following tabulation. Detailed cost estimates are presented in Appendix L.

	<i>Estimated Cost</i>	
	<i>Capital</i>	<i>Annual</i>
Uvas Dam and Reservoir-----	\$3,604,000	\$173,500
Uvas-Llagas Conduit -----	273,900	16,600
Llagas Creek Percolation Ponds	40,000	4,000
Totals -----	\$3,917,900	\$194,100

CHAPTER V

SUMMARY OF CONCLUSIONS, AND RECOMMENDATIONS

As a result of field investigation and study and analysis of available data on the water resources and water problems of the Santa Clara Valley, the following conclusions and recommendations are made:

SUMMARY OF CONCLUSIONS

1. There are two present basic water problems in the Santa Clara Valley. One of these is the threat of sea-water intrusion into the confined aquifers underlying North Santa Clara Valley, which results from a rate of ground water draft in excess of safe yield of the aquifers. The other problem is the progressive perennial lowering of ground water levels in forebay zones of the valley.

2. The present principal sources of water supply of the Santa Clara Valley are direct precipitation, runoff from the tributary drainage areas of the Diablo Range and Santa Cruz Mountains, and sub-surface inflow from beneath San Francisco Bay. There are no significant exports of water from the valley. However, a relatively small amount of water is imported to North Santa Clara Valley through the Hetch Hetchy system owned by the City of San Francisco.

3. The present mean seasonal requirement for supplemental water in the Santa Clara Valley is about 52,000 acre-feet, distributed as follows: North Santa Clara Valley, 45,000 acre-feet, and South Santa Clara Valley, 7,000 acre-feet.

4. Under conditions of ultimate development, the probable seasonal requirements for supplemental water in North and South Santa Clara Valleys should approximate 262,000 and 21,000 acre-feet, respectively.

5. The surface and ground water supplies of the Santa Clara Valley generally are of good mineral quality, and suitable for irrigation and other purposes.

6. The estimated safe seasonal yield of the ground water basins of North and South Santa Clara Valleys is about 134,000 and 39,000 acre-feet, respectively.

7. The present seasonal extraction of ground water from North Santa Clara Valley in the amount of about 179,000 acre-feet exceeds the safe yield by about 45,000 acre-feet. Corresponding ground water extraction of South Santa Clara Valley in the amount of about 46,000 acre-feet per season exceeds the safe yield by about 7,000 acre-feet.

8. An immediate source of supplemental water is available locally to the Santa Clara Valley in waters

of the surface streams that presently waste to San Francisco Bay and the Pajaro River. Salvage of this water would involve the development of both surface and ground water storage capacity. It is indicated that the present mean seasonal waste of water from North Santa Clara Valley to San Francisco Bay, with recently completed works in operation, is about 53,000 acre-feet, excluding the estimated 12,300 acre-feet presently wasting from San Francisquito Creek. The indicated mean seasonal waste of water from South Santa Clara Valley to the Pajaro River is about 49,000 acre-feet. It would be feasible to salvage a portion of these presently wasted waters. However, complete salvage of such waters would be insufficient to meet the probable ultimate supplemental water requirements.

9. Satisfaction of the ultimate water requirements in the Santa Clara Valley will require an import of some 213,000 acre-feet of water per season from a source or sources outside the valley.

10. Completion of the works under construction by the Santa Clara Valley Water Conservation District and the proposed Calero-Los Gatos Conduit, and their operation as proposed in this bulletin, would eliminate the present overdraft and provide a small amount of additional supplemental water in the Forebay Zone of North Santa Clara Valley. Construction and operation of the Coyote Valley Well Field, the Coyote Valley-San Jose Pipe Line, and the Little Francis Project would reduce the overdraft in the Pressure Zone of North Santa Clara Valley by about 12,500 acre-feet per season. Taking into consideration the yield of about 5,000 acre-feet per season from Lake Elsmann, the remaining overdraft in the Pressure Zone would be about 1,500 acre-feet per season.

11. Completion and operation of Chesbro Dam and Reservoir on Llagas Creek by the South Santa Clara Valley Water Conservation District should reduce the present overdraft in South Santa Clara Valley by about 5,700 acre-feet per season. Construction and operation of Uvas Dam and Reservoir on Uvas Creek, with a storage capacity of 34,000 acre-feet as proposed herein, and construction and operation of the proposed Llagas Creek Percolation Ponds, would eliminate the present overdraft in South Santa Clara Valley, and provide for the probable ultimate supplemental water requirement.

12. Additional water could be developed for use in North Santa Clara Valley by construction of the Zayante Project. The estimated safe seasonal yield of this project is about 4,000 acre-feet.

13. The ultimate supplemental water requirement of North Santa Clara Valley would be largely provided for by importation of water from the Sacramento-San Joaquin Delta under the authorized Feather River Project. In the report of the Division of Water Resources on "Program for Financing and Constructing the Feather River Project as the Initial Unit of The California Water Plan", February, 1955, charges for Feather River Project water delivered to the Santa Clara Valley were assumed at from \$17.50 to \$22.50 per acre-foot, based on an initial project to provide 120,000 acre-feet of water per season to San Benito County, Santa Clara Valley, and Alameda County.

14. Based on 1954 prices, the unit cost of the 8,900 acre-feet of yield of new water provided by the Northern Valley Project for North Santa Clara Valley would be about \$17.00 per acre-foot, excluding costs of pumping the water from the ground water basin. Unit costs of the 3,000 acre-feet of water per season conserved by the Little Francis Project would be about \$74.00 per acre-foot, and for the 4,000 acre-feet of safe seasonal yield from the Zayante Project the unit costs would be about \$45.00 per acre-foot.

15. The unit cost of the 16,300 acre-feet per season of yield of new water for South Santa Clara Valley

from the Uvas and Llagas Creeks Project would be about \$12.00 per acre-foot.

RECOMMENDATIONS

It is recommended that the County of Santa Clara, and the agencies therein responsible for furnishing water supplies in the Santa Clara Valley:

1. Initiate studies to determine the effects of recently completed water development projects on the safe yield of ground water basins in the Santa Clara Valley.

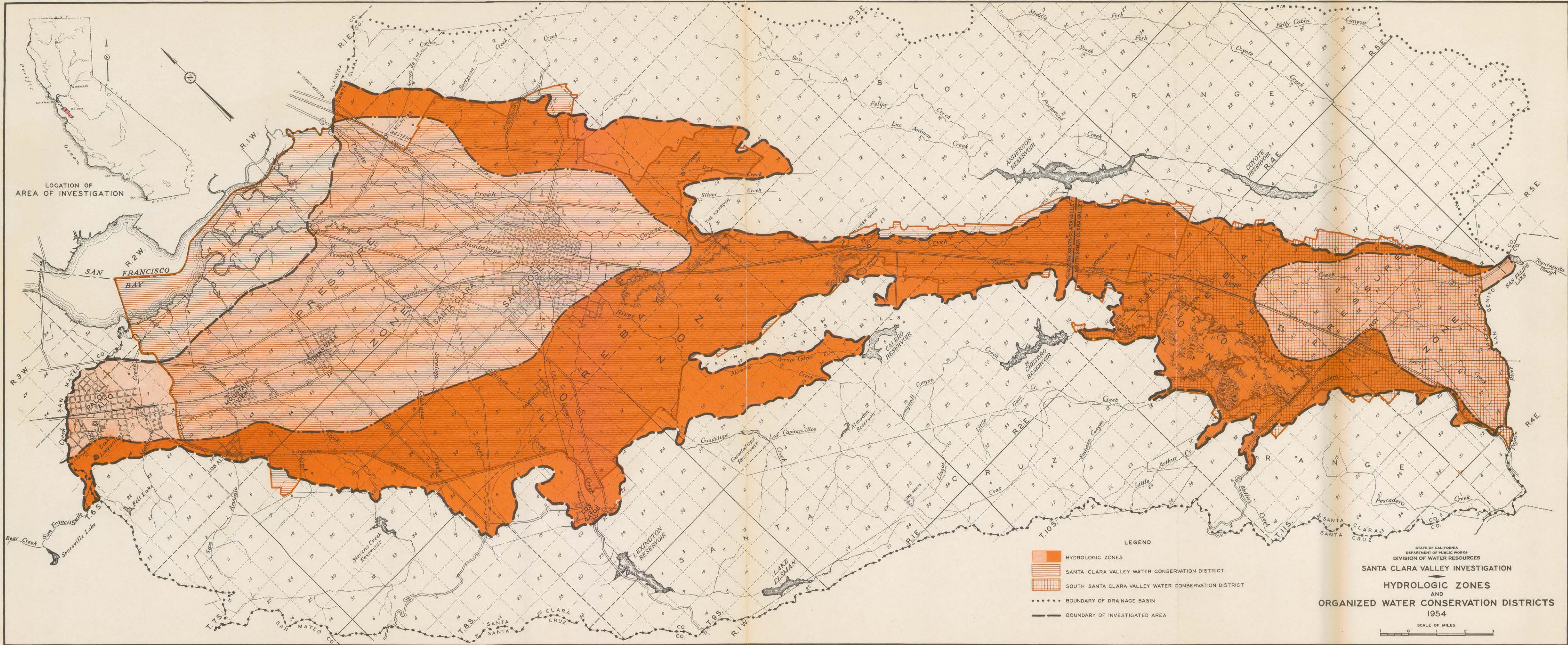
2. Initiate studies to determine the most feasible way to supply supplemental water to the Pressure Zone of North Santa Clara Valley.

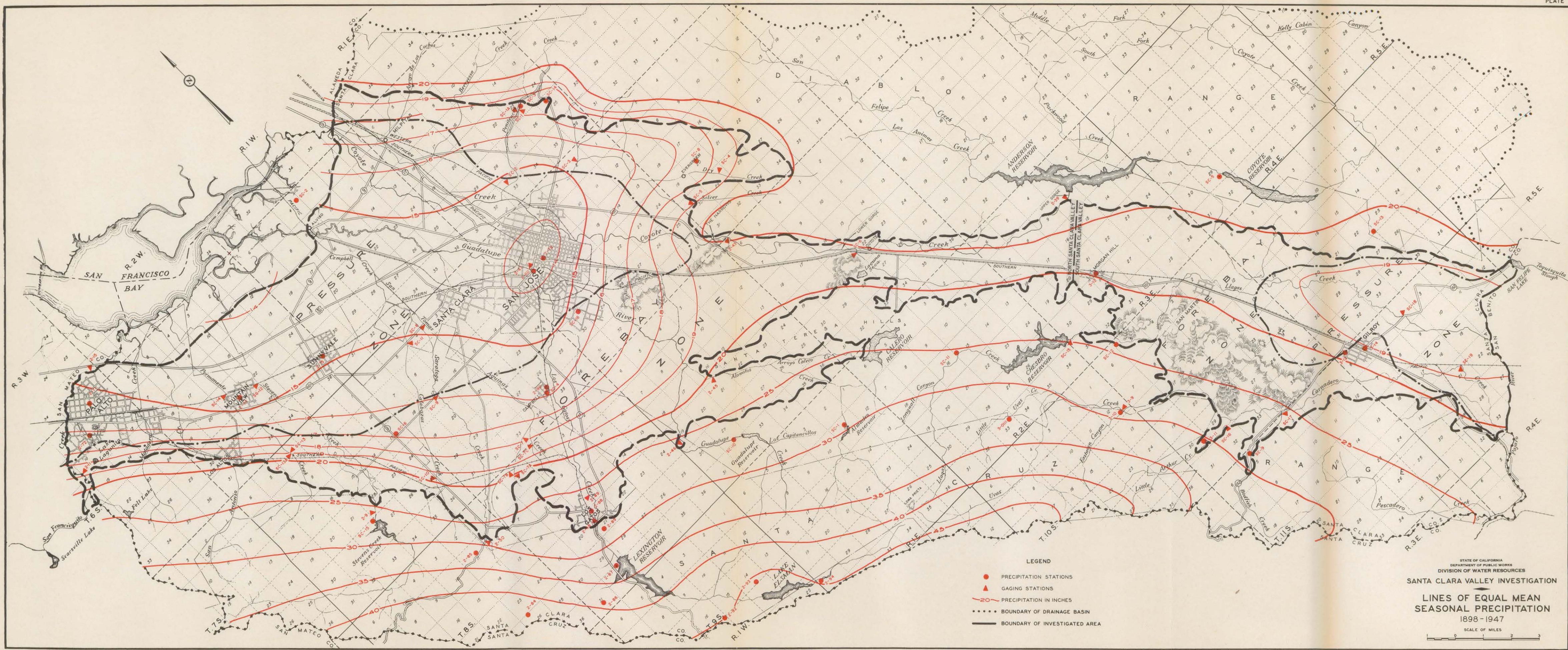
3. Proceed with their planned local projects for water resource development as far as is practicable.

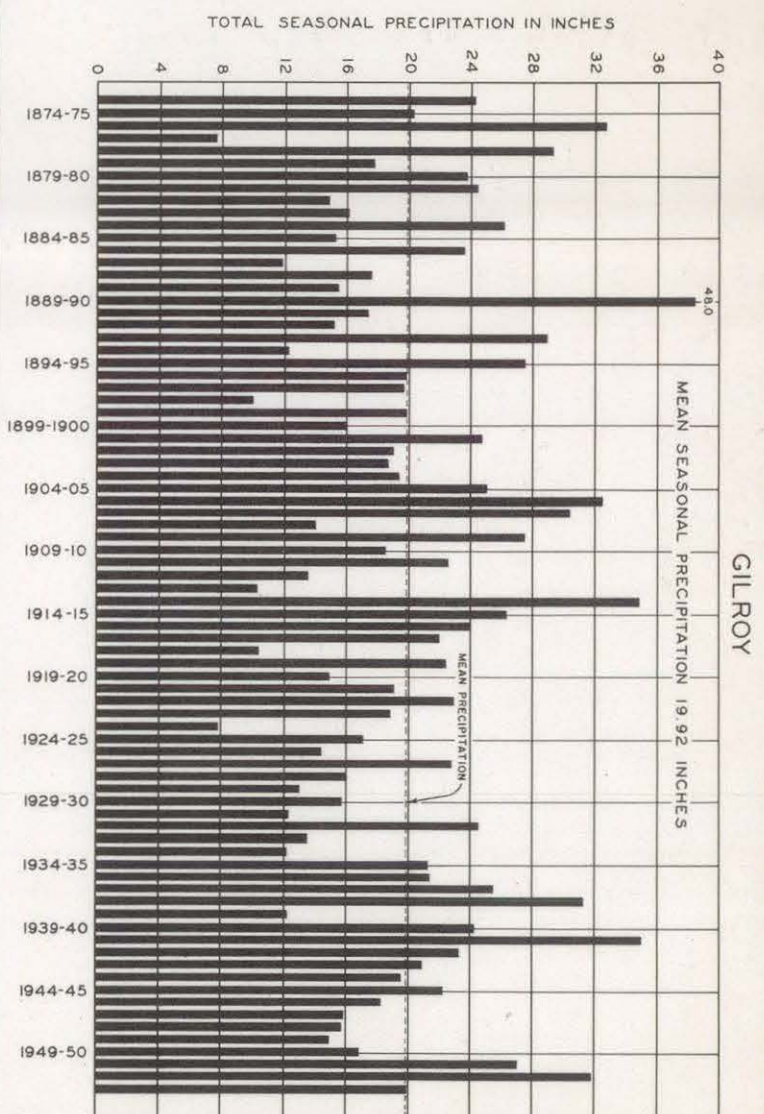
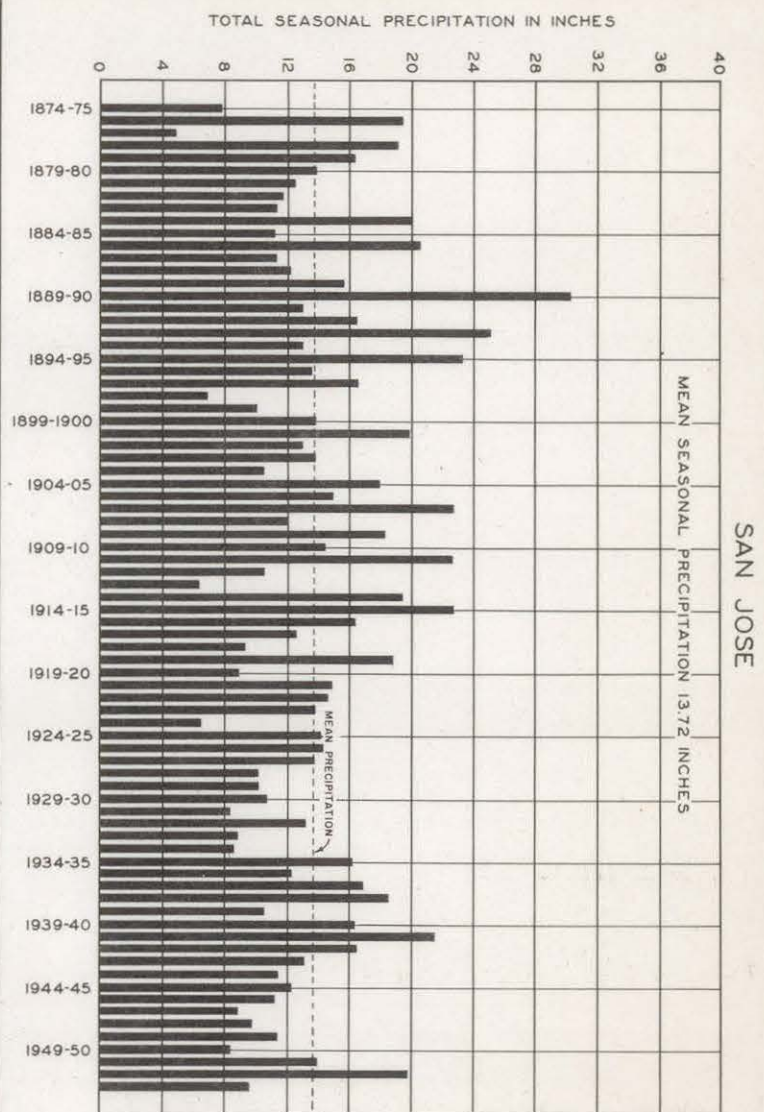
4. Proceed with development of the Northern Valley Project and the Uvas and Llagas Creeks Project, as set forth in this bulletin.

5. Give early consideration to the implementation of plans for securing a water supply from the Feather River Project to supplement local supplies.

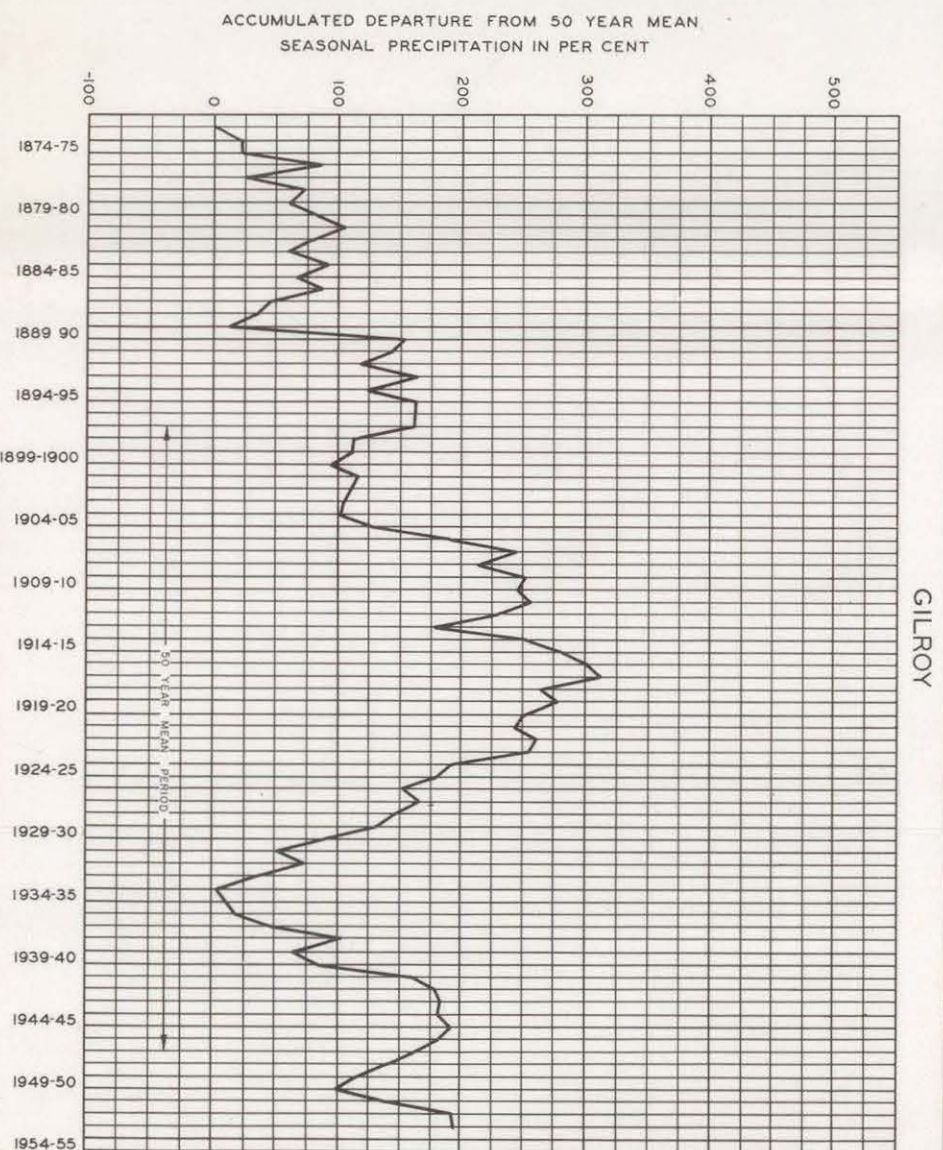
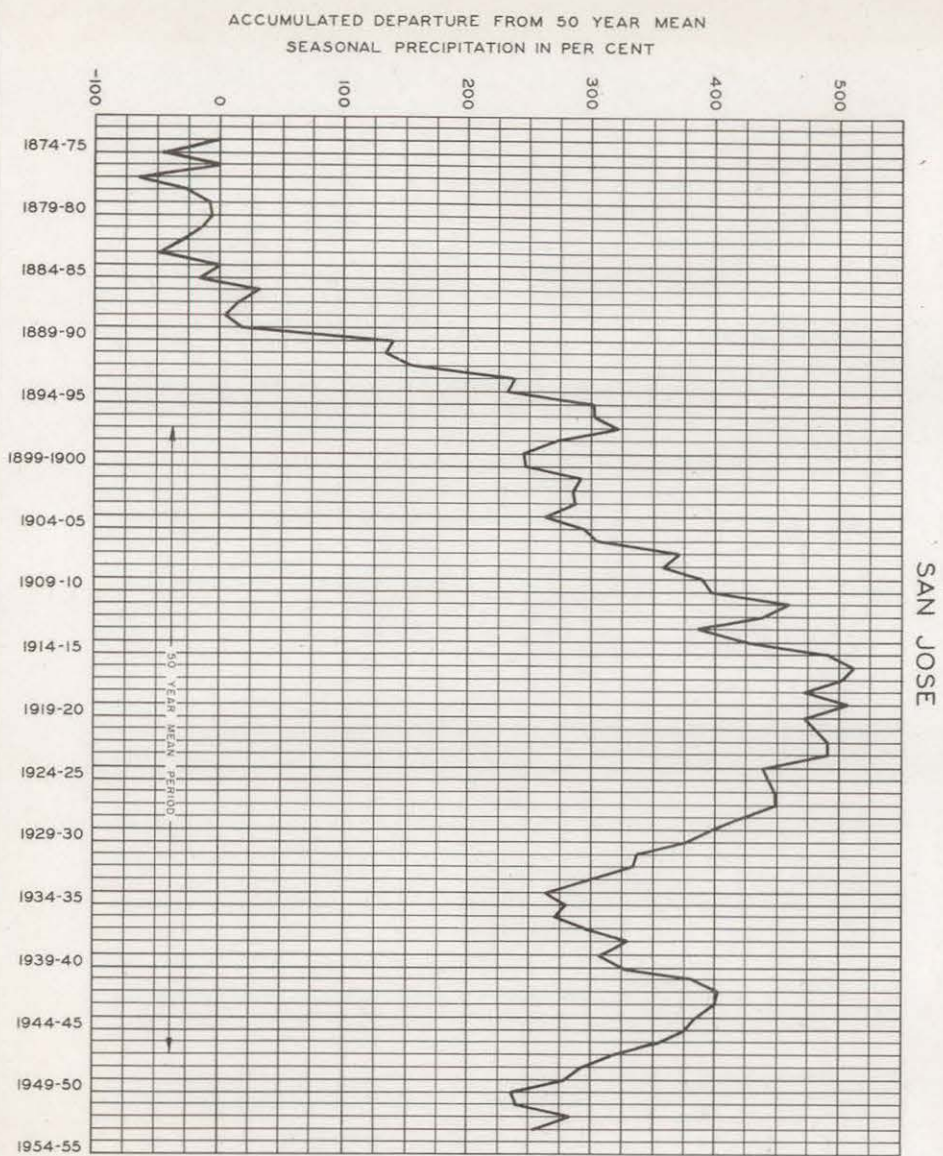
6. Initiate a program for the acquisition of lands, easements, and rights of way necessary for the construction of required water conservation works.



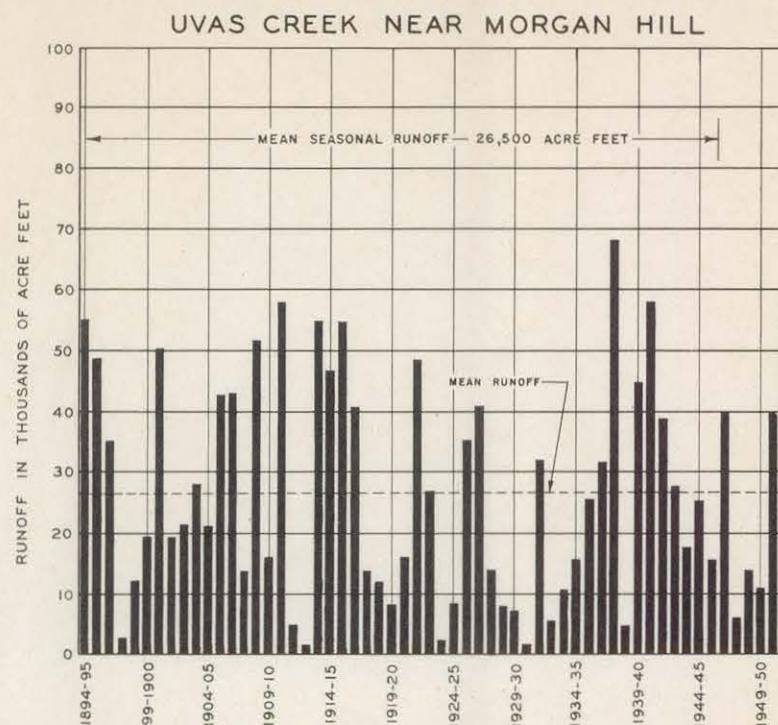
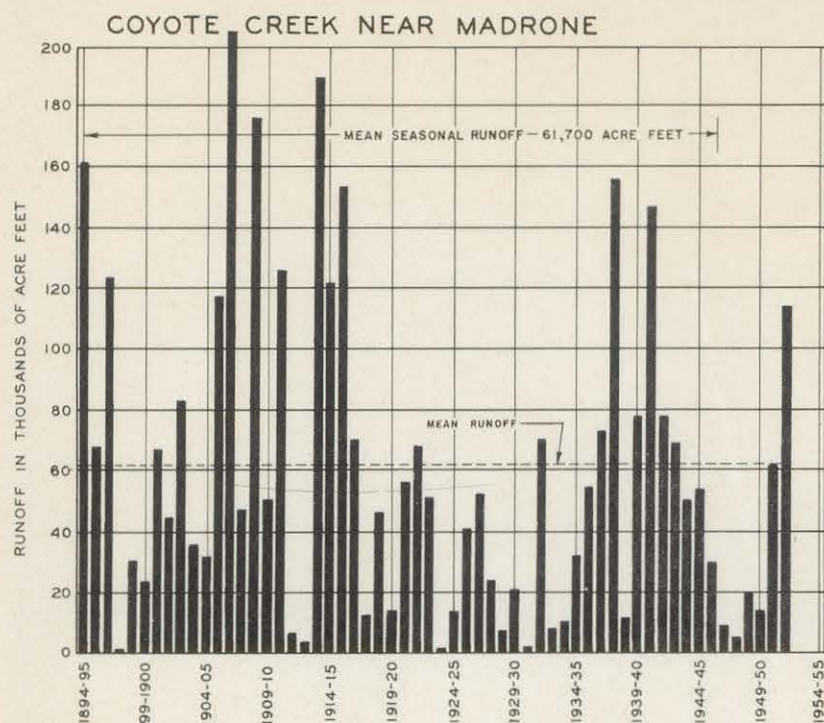




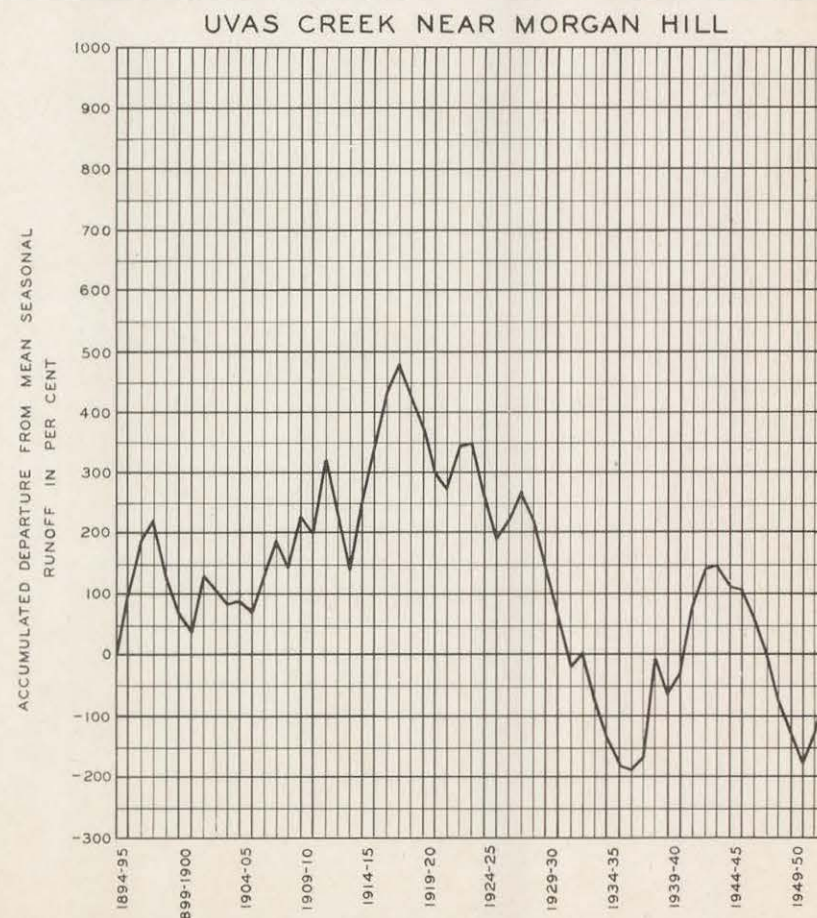
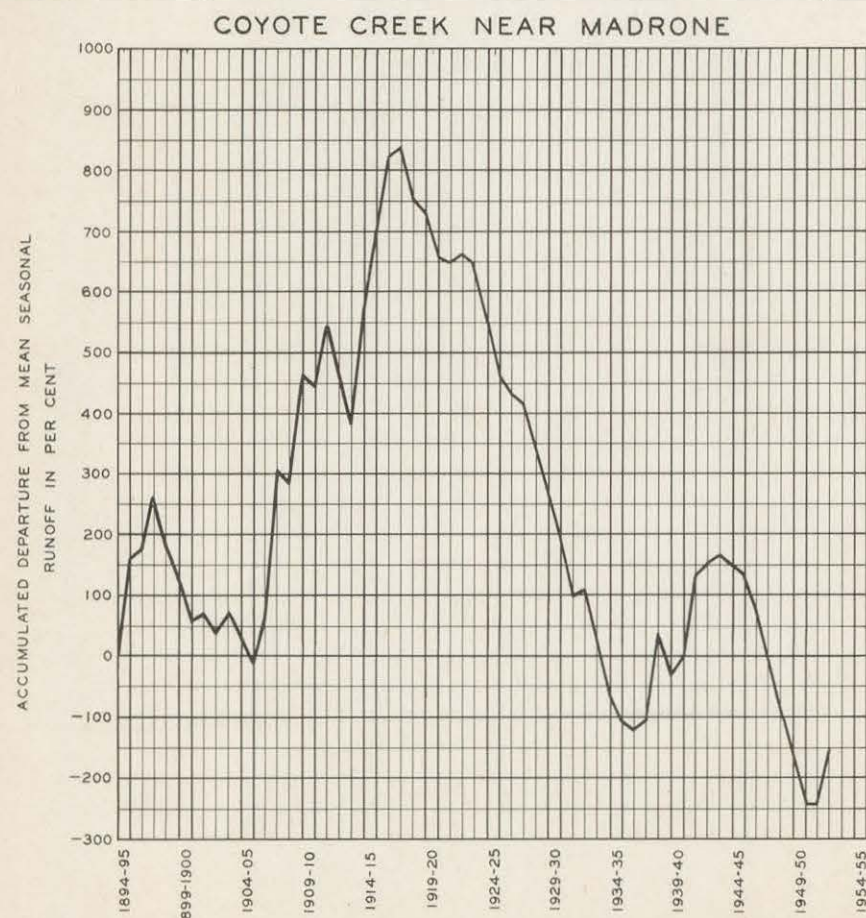
RECORDED SEASONAL PRECIPITATION AT SAN JOSE AND GILROY



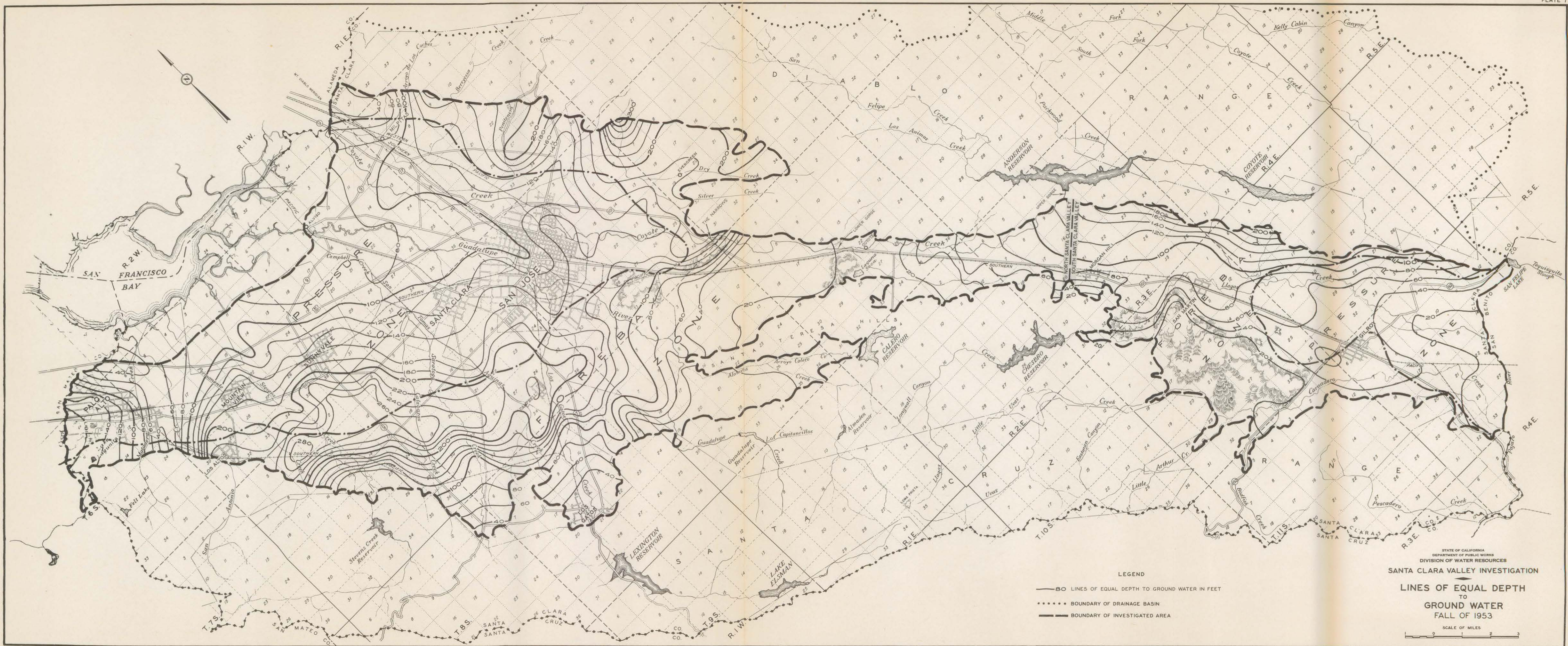
ACCUMULATED DEPARTURE FROM MEAN SEASONAL PRECIPITATION AT SAN JOSE AND GILROY

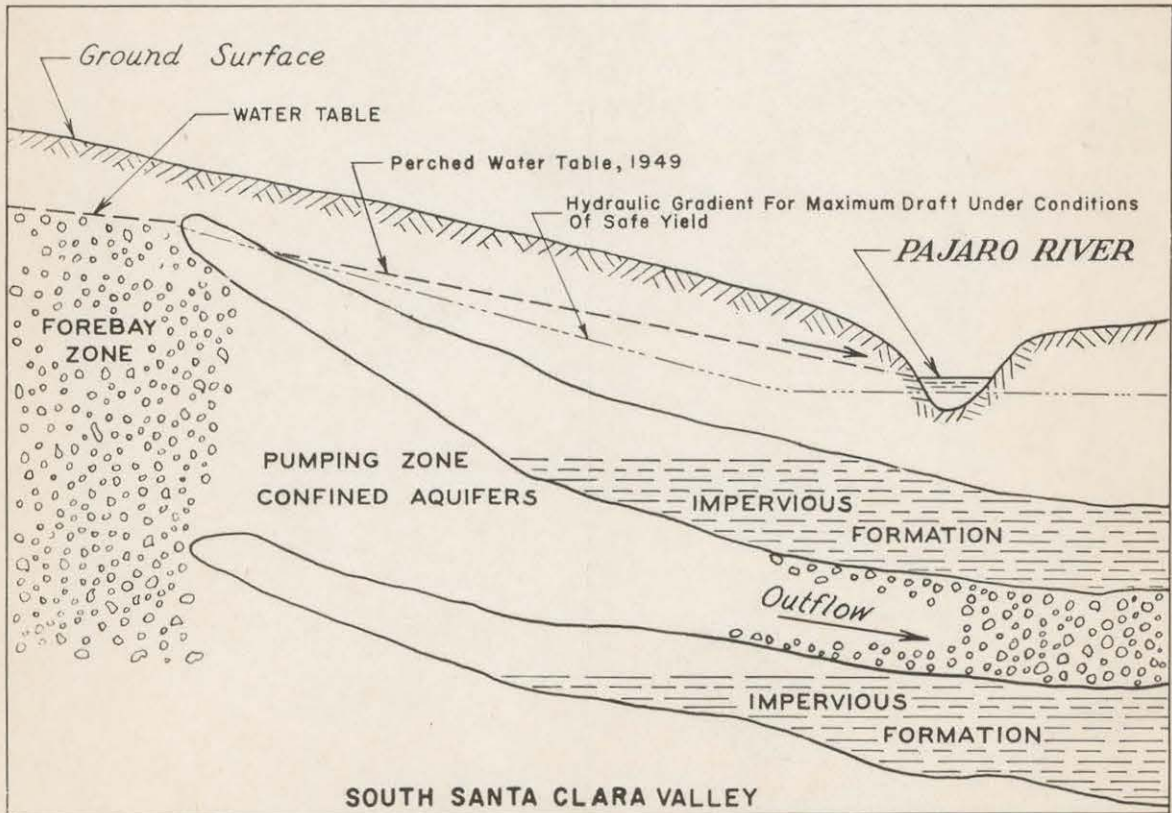
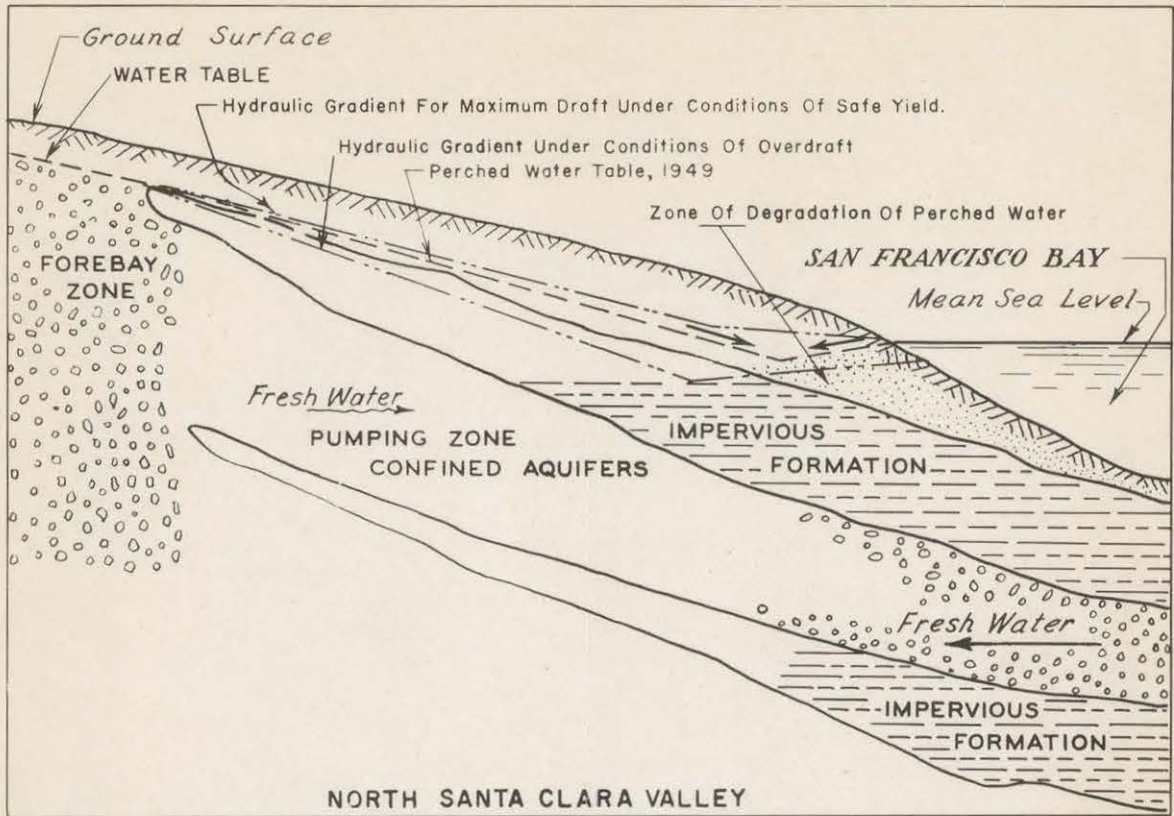


RECORDED AND ESTIMATED SEASONAL NATURAL RUNOFF

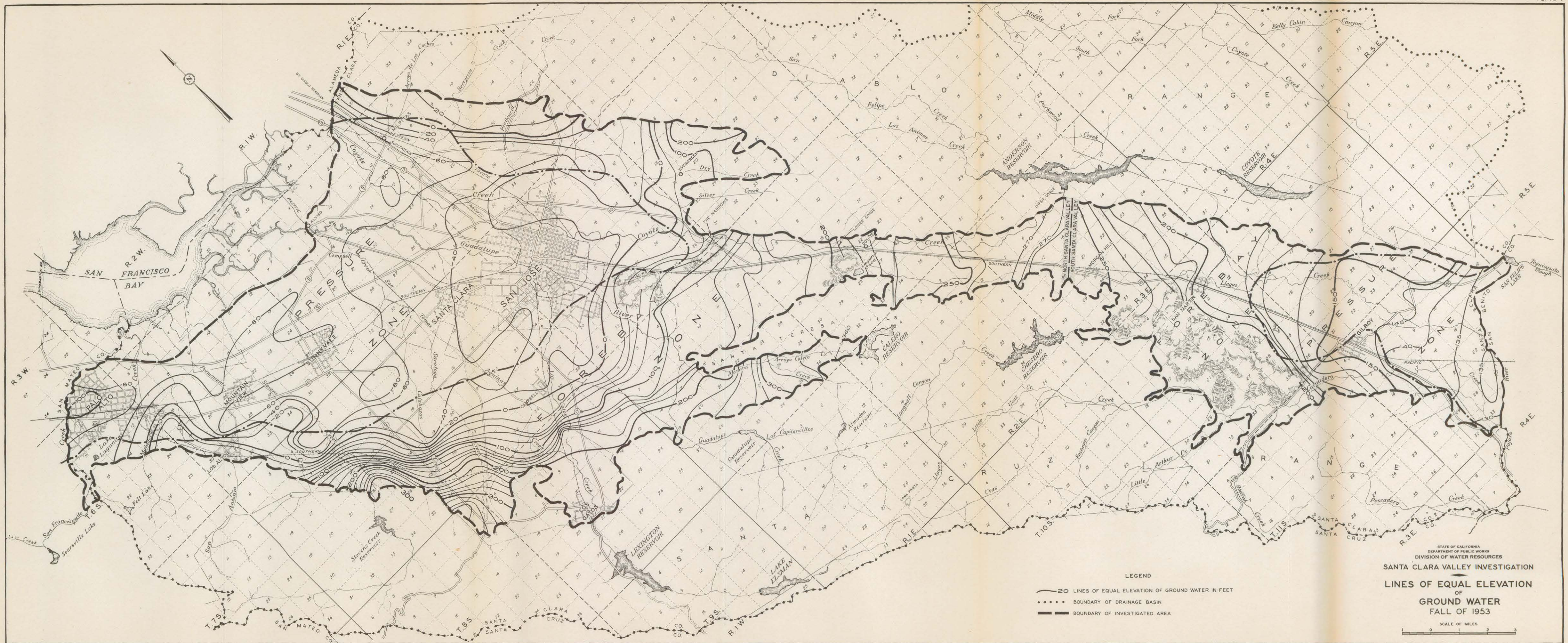


ACCUMULATED DEPARTURE FROM MEAN SEASONAL NATURAL RUNOFF





DIAGRAMMATIC PROFILES OF PRESSURE AND FOREBAY ZONES
IN NORTH AND SOUTH SANTA CLARA VALLEYS



LEGEND

— 20 LINES OF EQUAL ELEVATION OF GROUND WATER IN FEET

..... BOUNDARY OF DRAINAGE BASIN

— BOUNDARY OF INVESTIGATED AREA

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

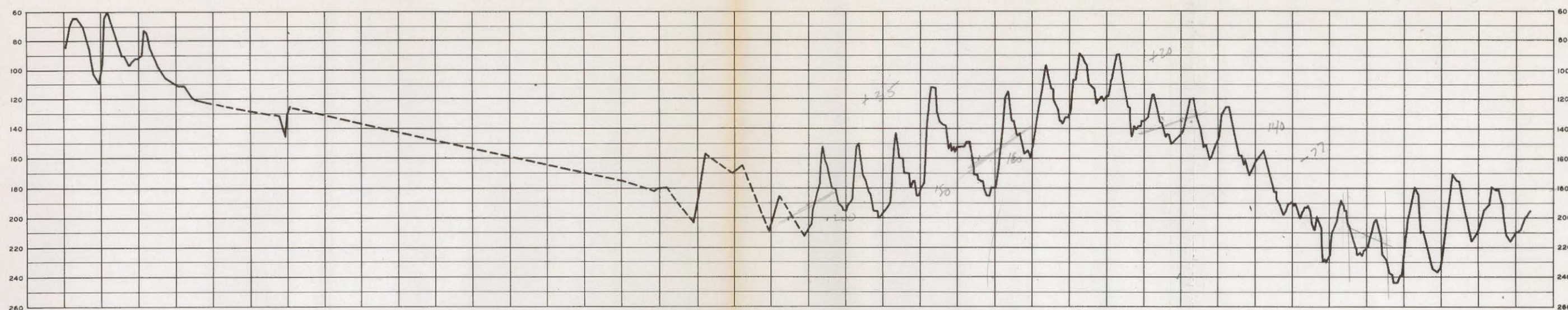
SANTA CLARA VALLEY INVESTIGATION

—

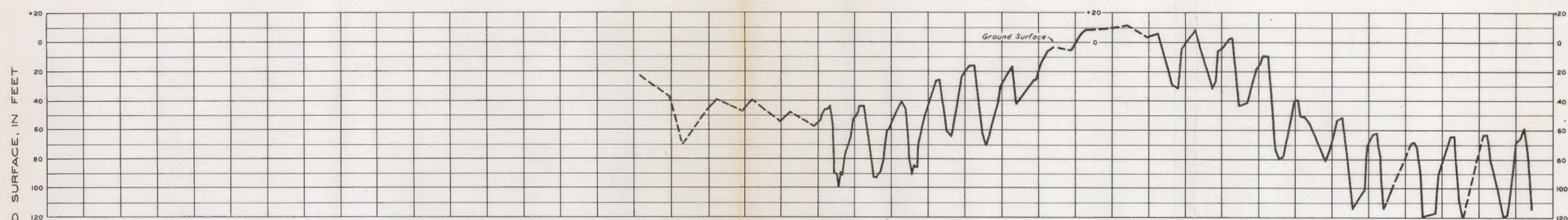
LINES OF EQUAL ELEVATION
OF
GROUND WATER
FALL OF 1953

SCALE OF MILES

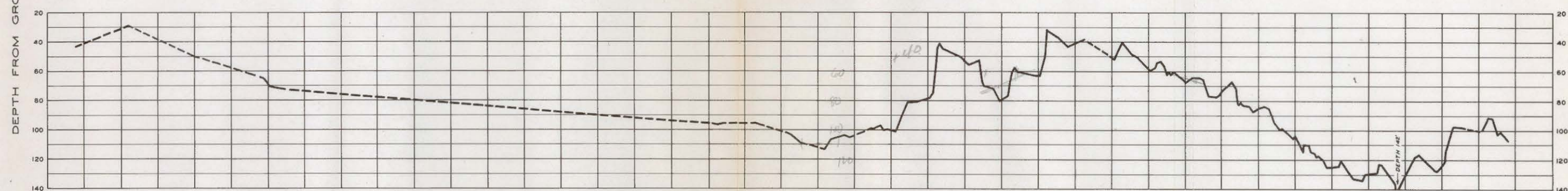
0 1 2 3



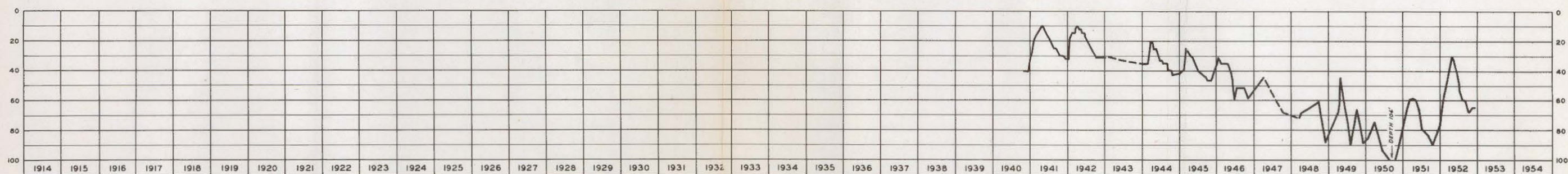
NORTH SANTA CLARA VALLEY-FOREBAY ZONE -WELL 7S/IW-35C1



NORTH SANTA CLARA VALLEY-PRESSURE ZONE -WELL 6S/IE-30MI

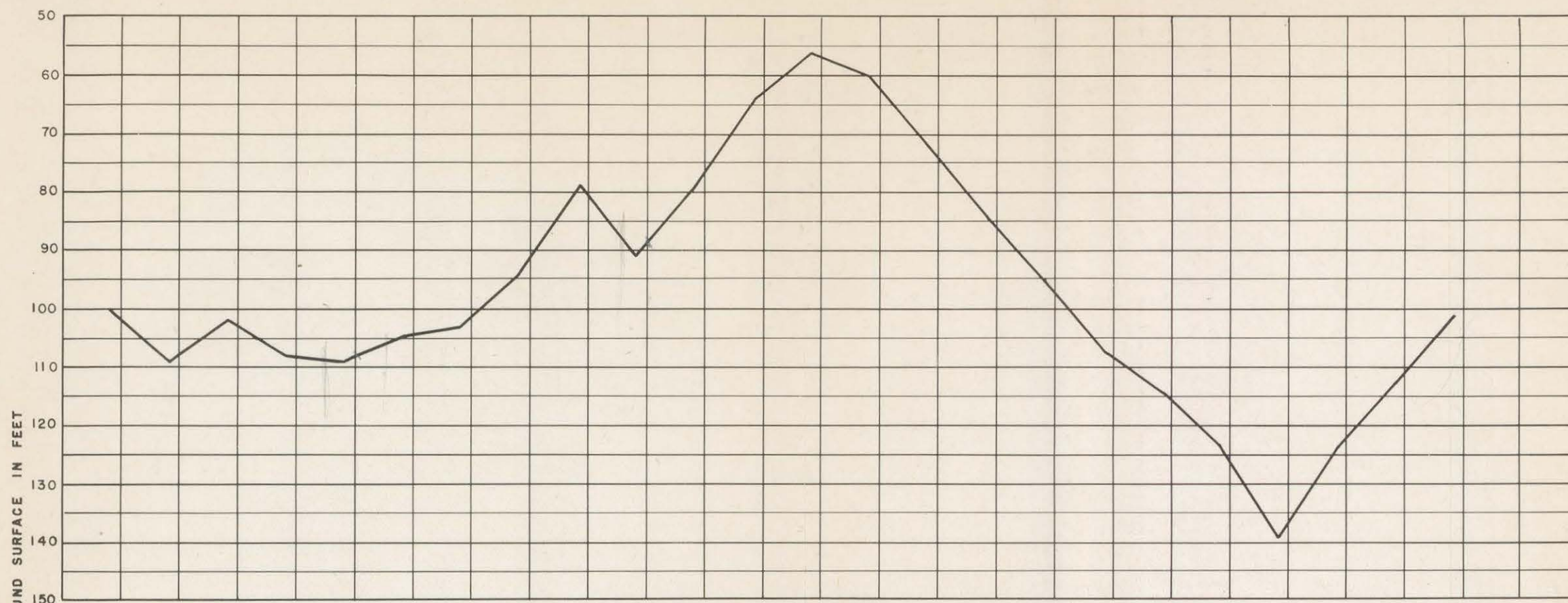


SOUTH SANTA CLARA VALLEY-FOREBAY ZONE -WELL 9S/3E-27C2

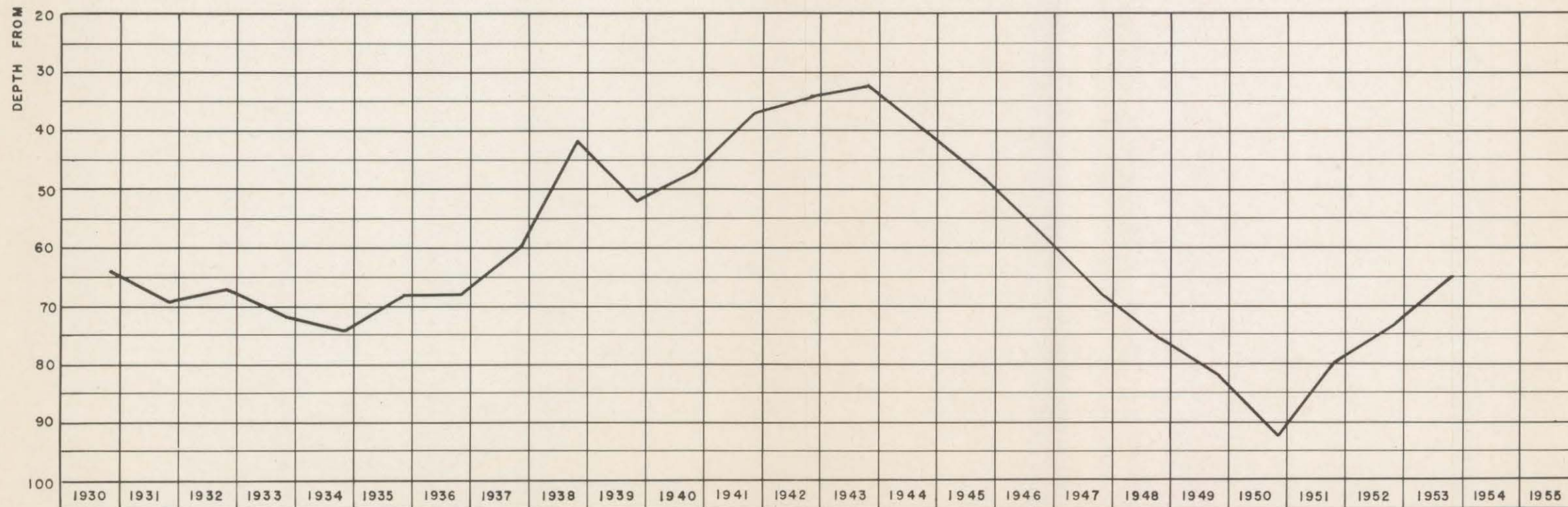


SOUTH SANTA CLARA VALLEY-PRESSURE ZONE -WELL 10S/3E-13R1

MEASURED DEPTH TO WATER LEVEL AT SELECTED WELLS IN SANTA CLARA VALLEY

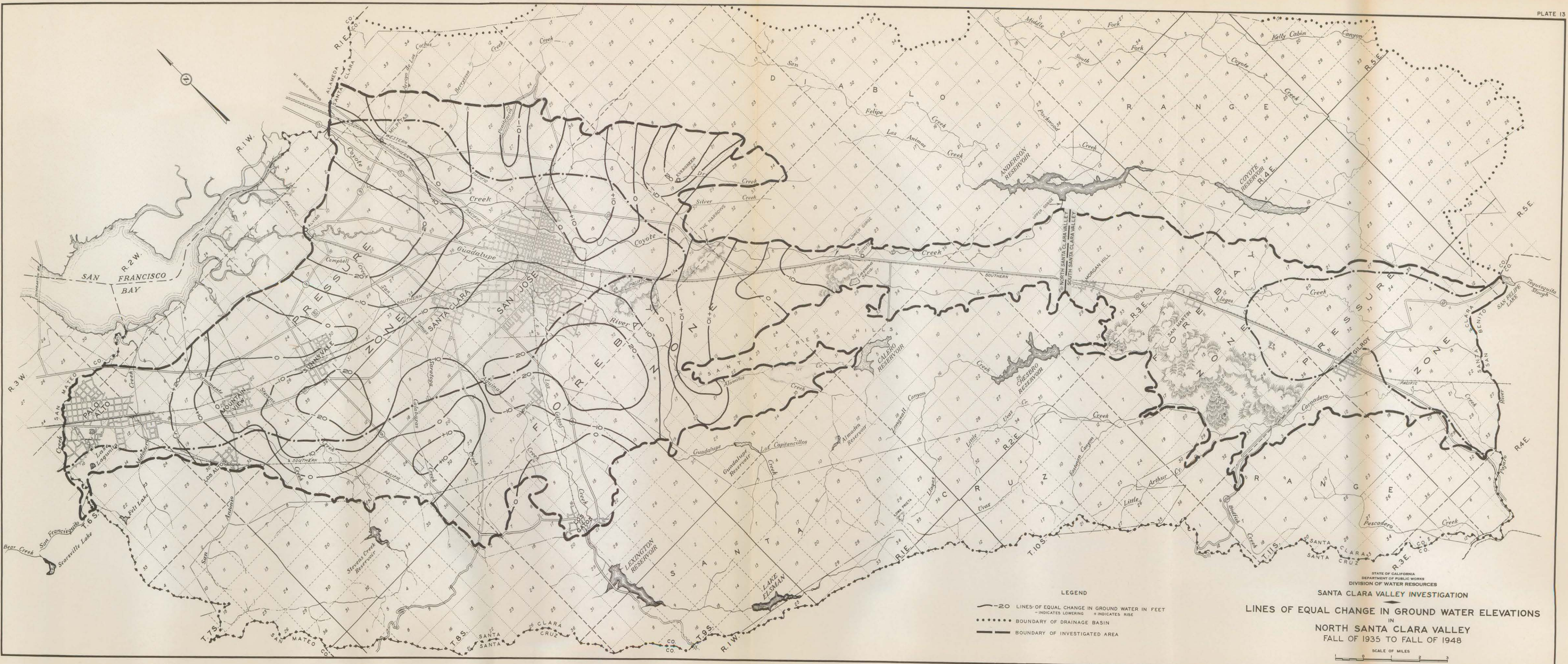


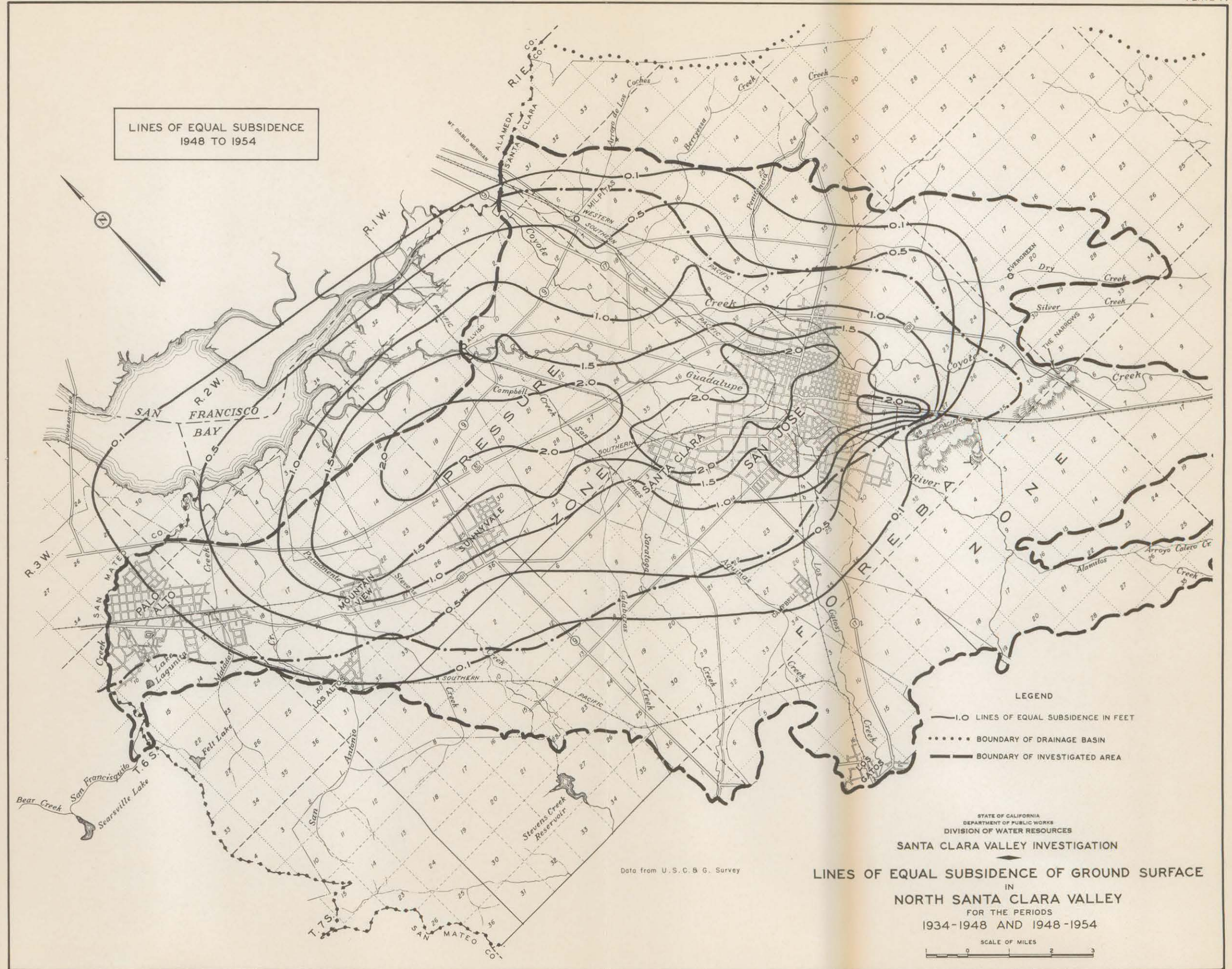
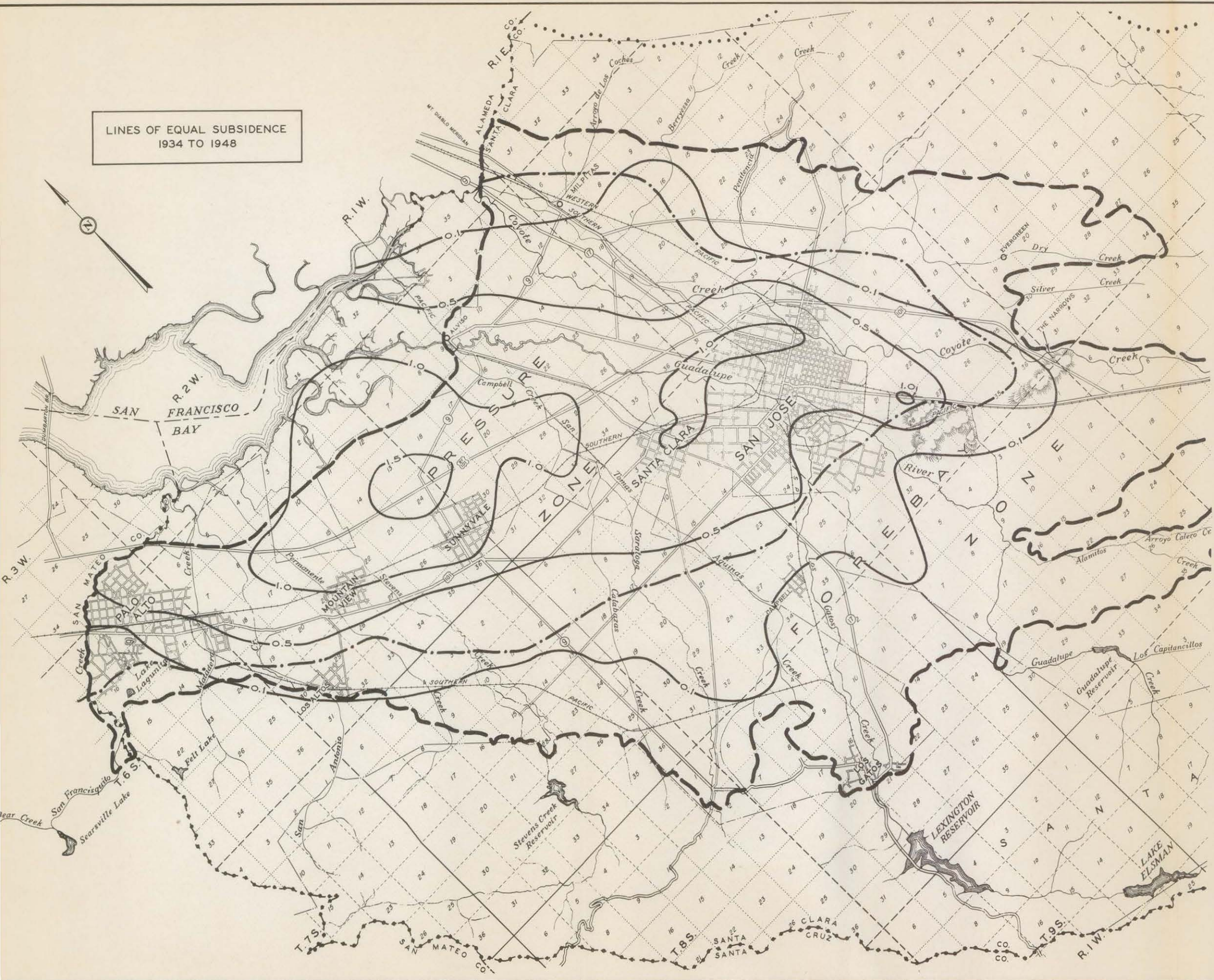
NORTH SANTA CLARA VALLEY

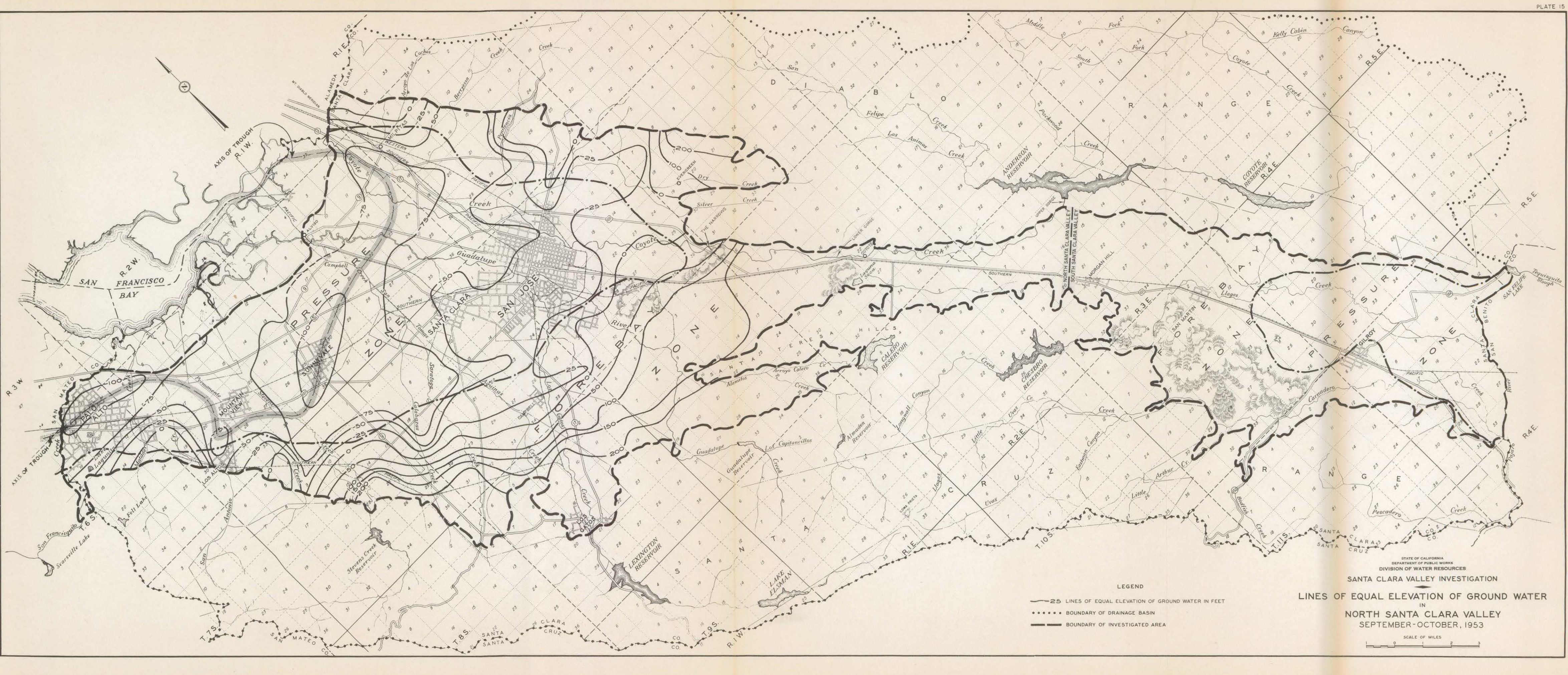


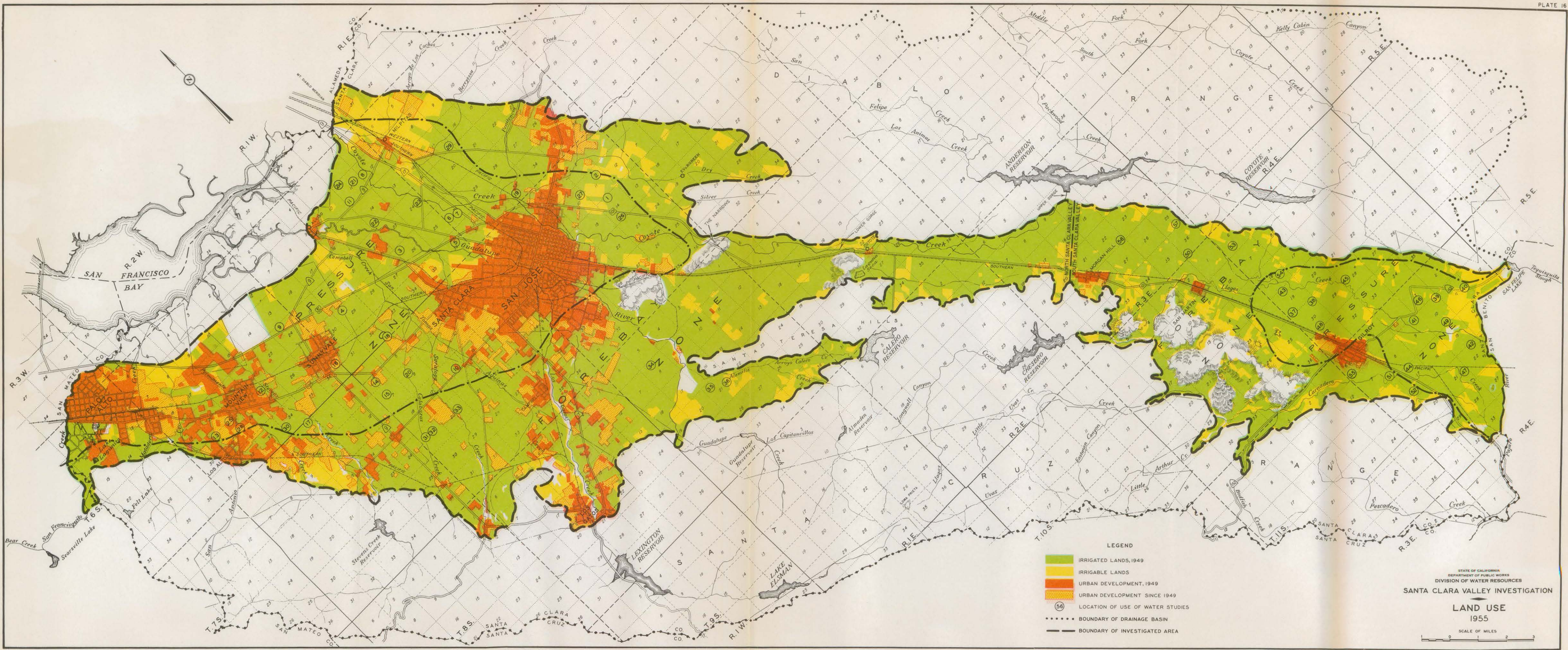
SOUTH SANTA CLARA VALLEY

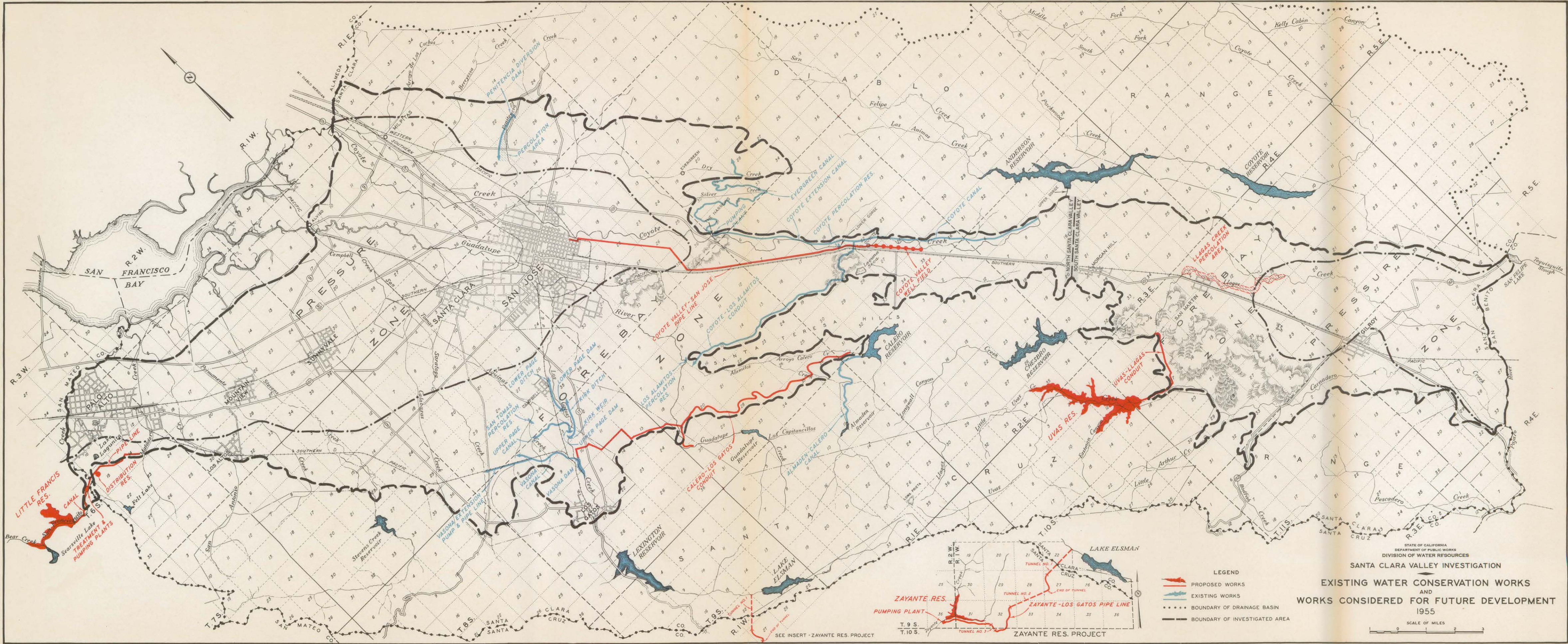
AVERAGE FALL DEPTH TO GROUND WATER IN FOREBAY ZONES

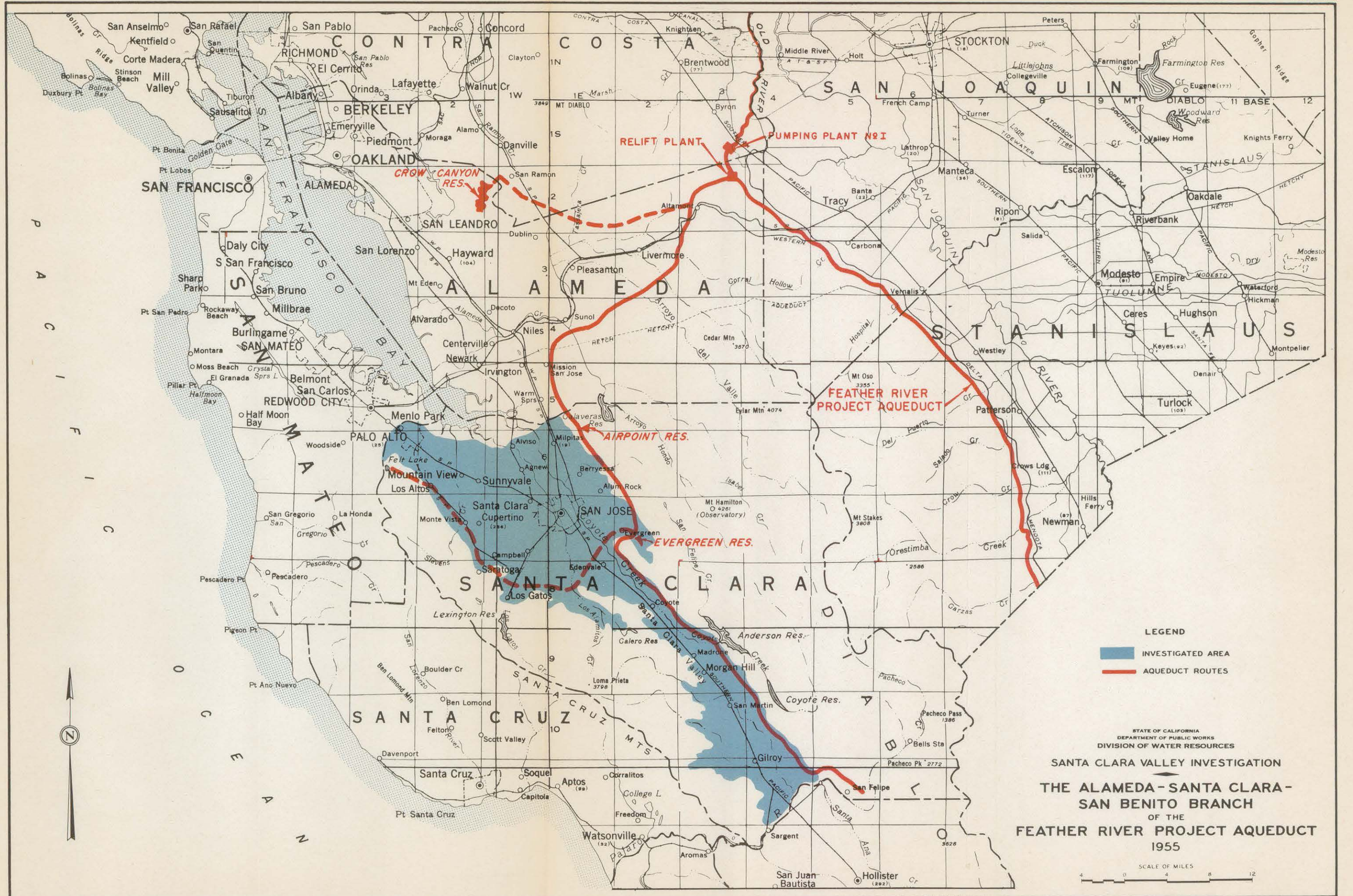


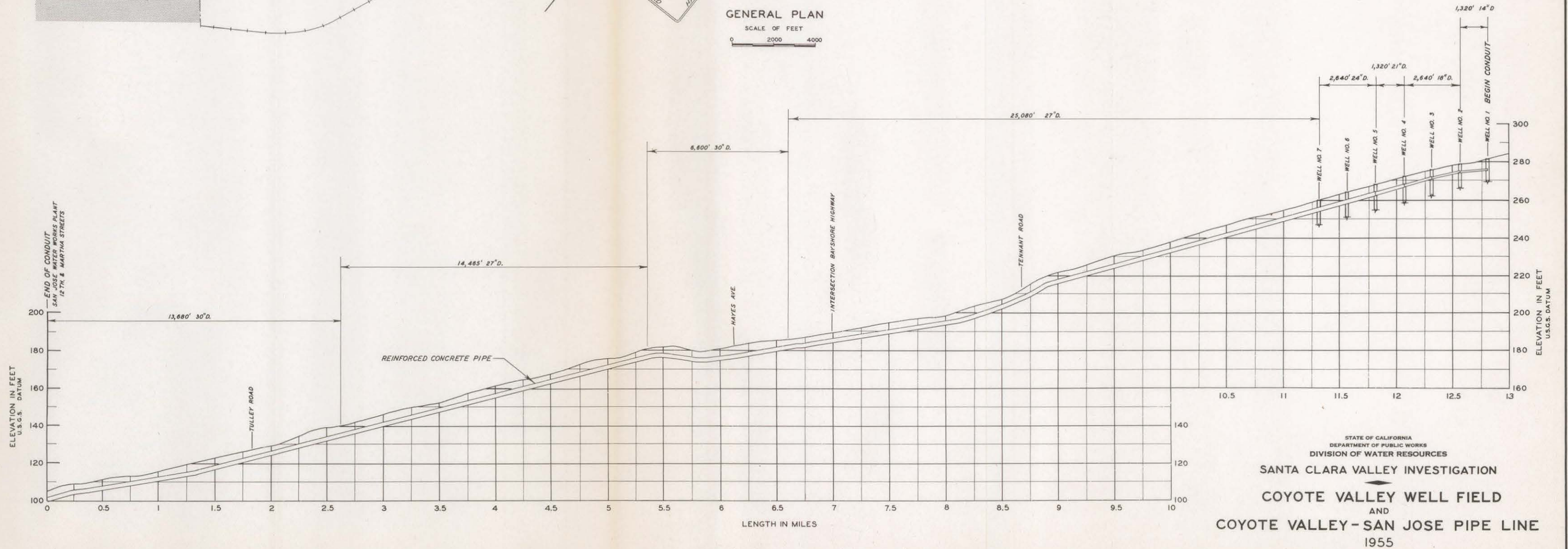
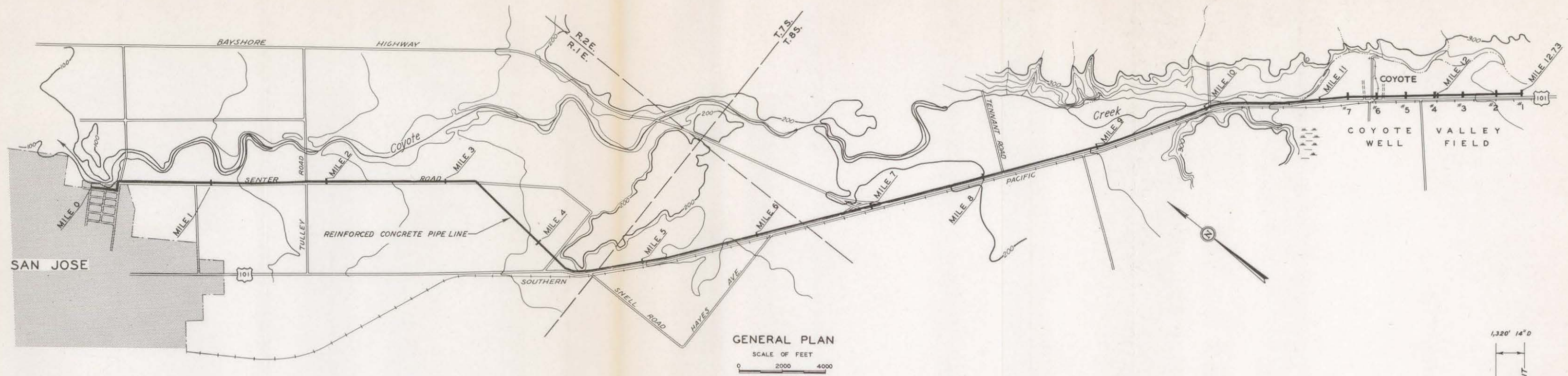


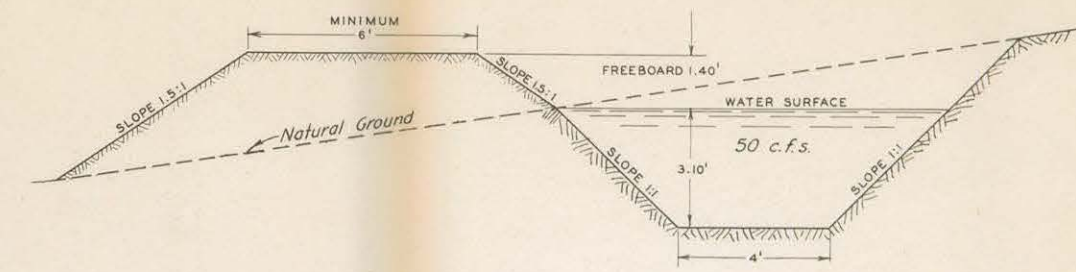
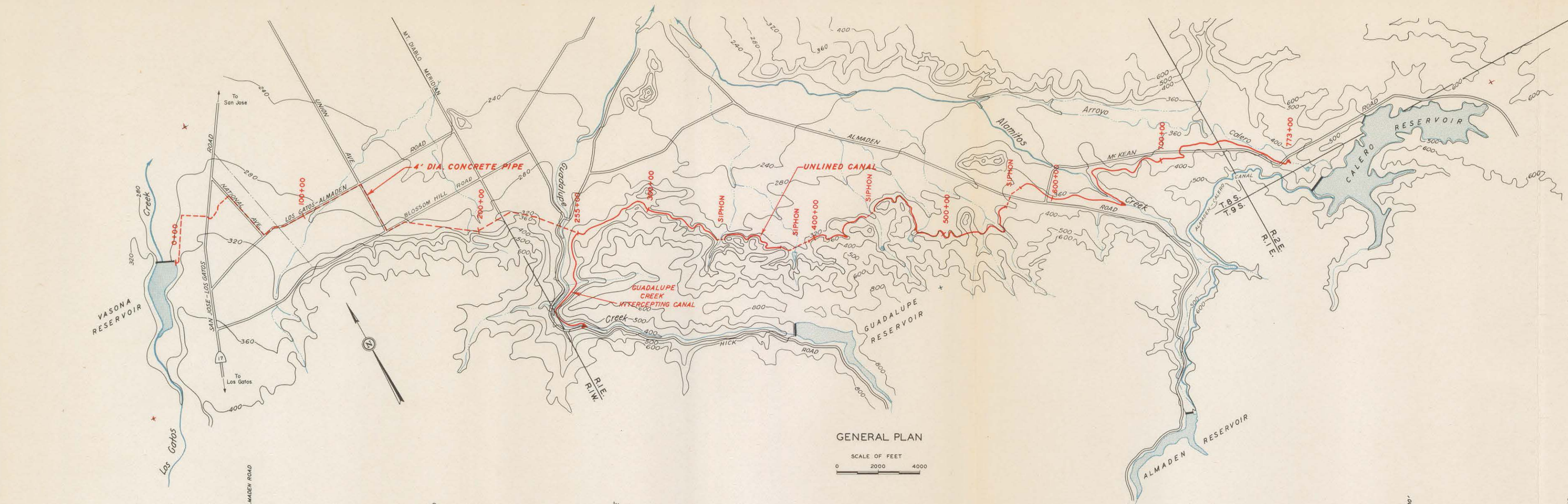






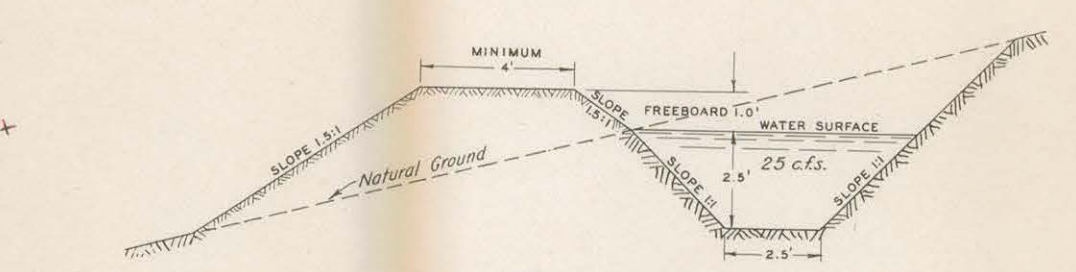






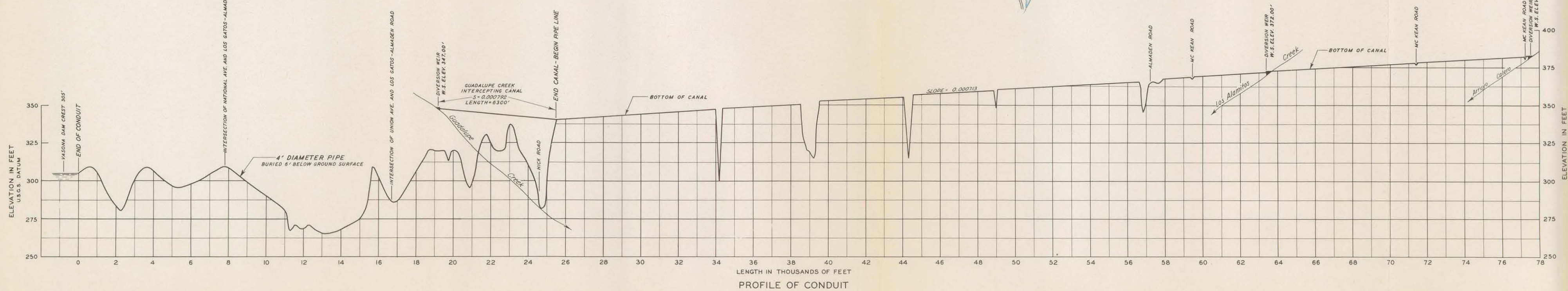
SECTION OF CANAL

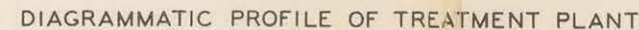
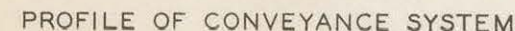
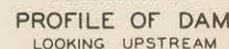
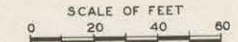
SCALE OF FEET
0 1 2 3 4 5

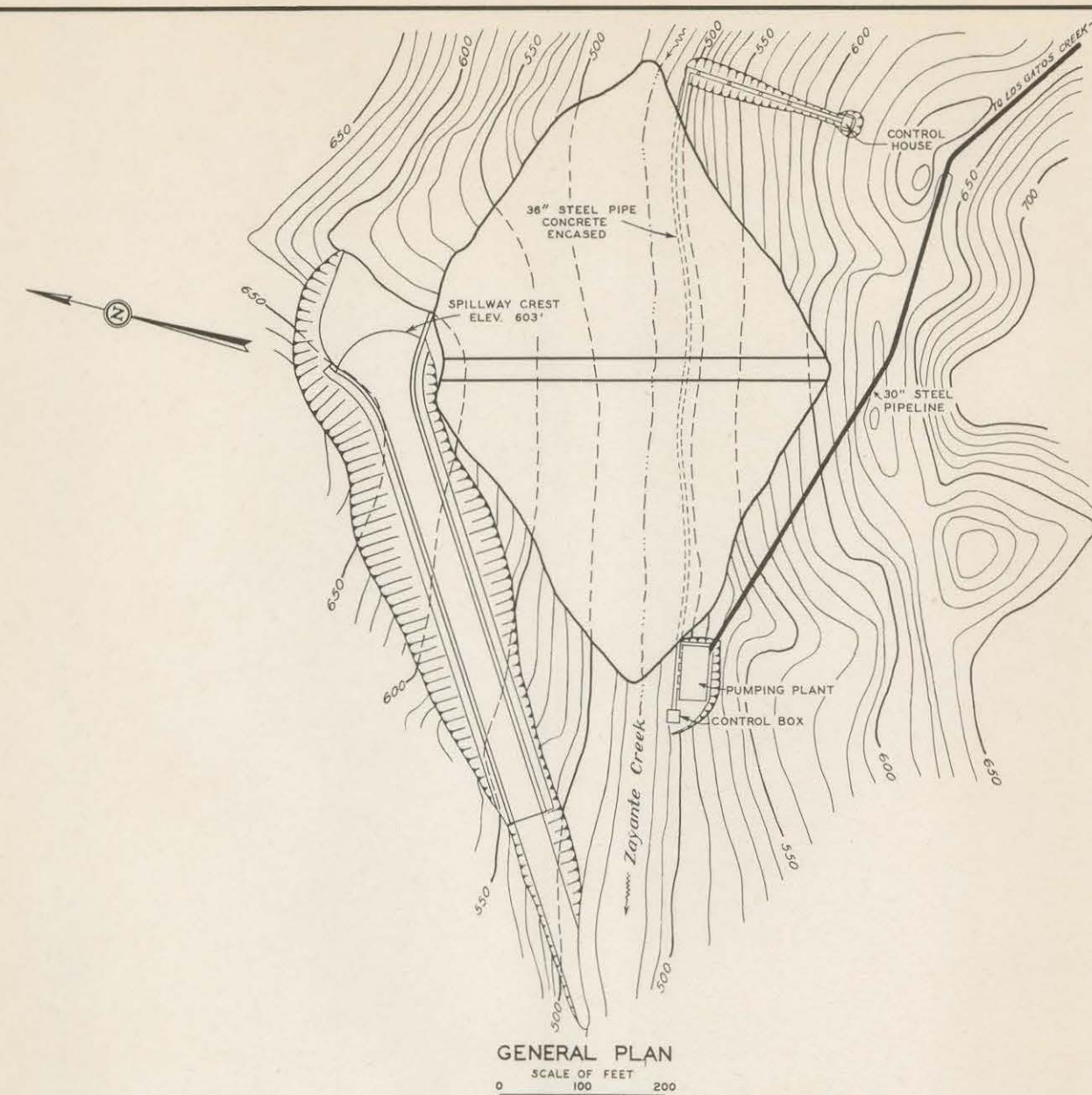


SECTION OF INTERCEPTING CANAL

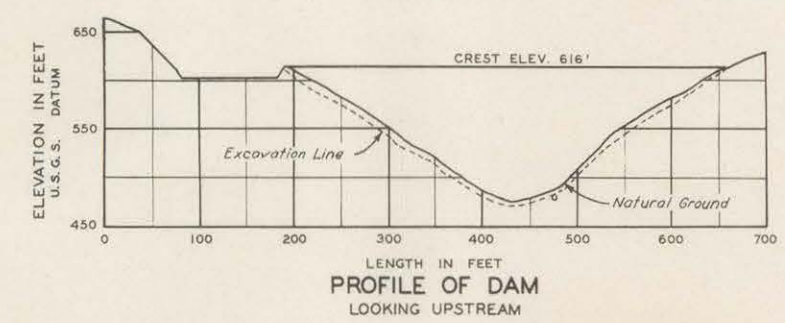
SCALE OF FEET
0 1 2 3 4 5



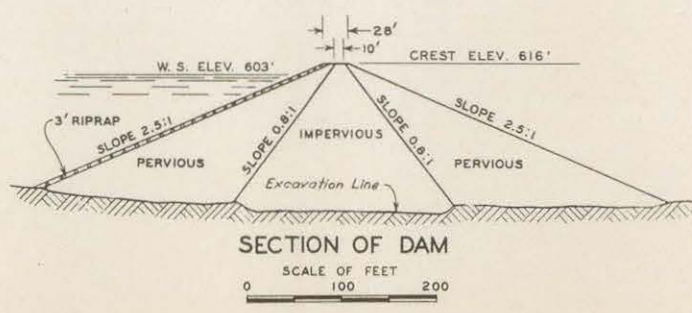




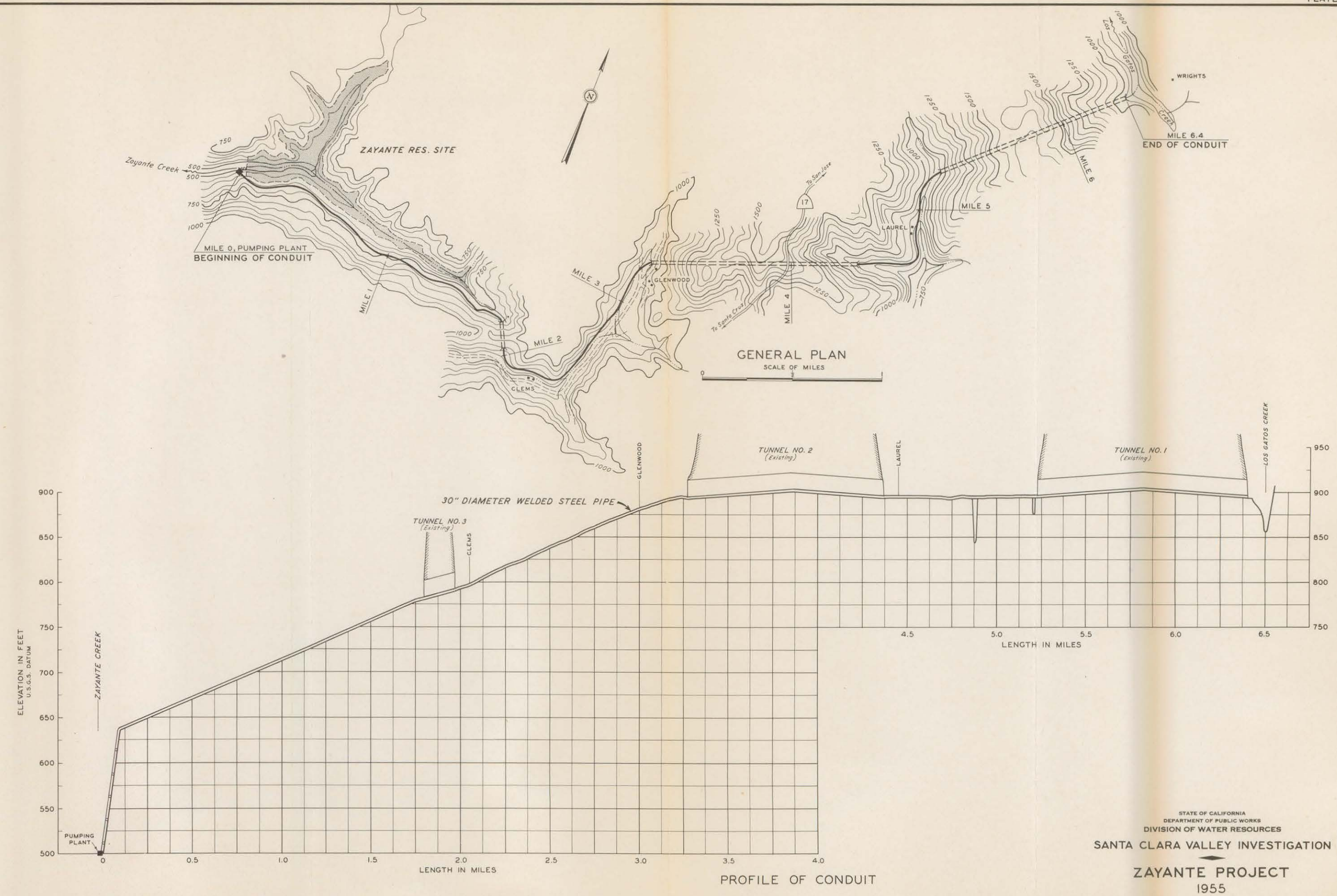
GENERAL PLAN
SCALE OF FEET
0 100 200



PROFILE OF DAM
LOOKING UPSTREAM

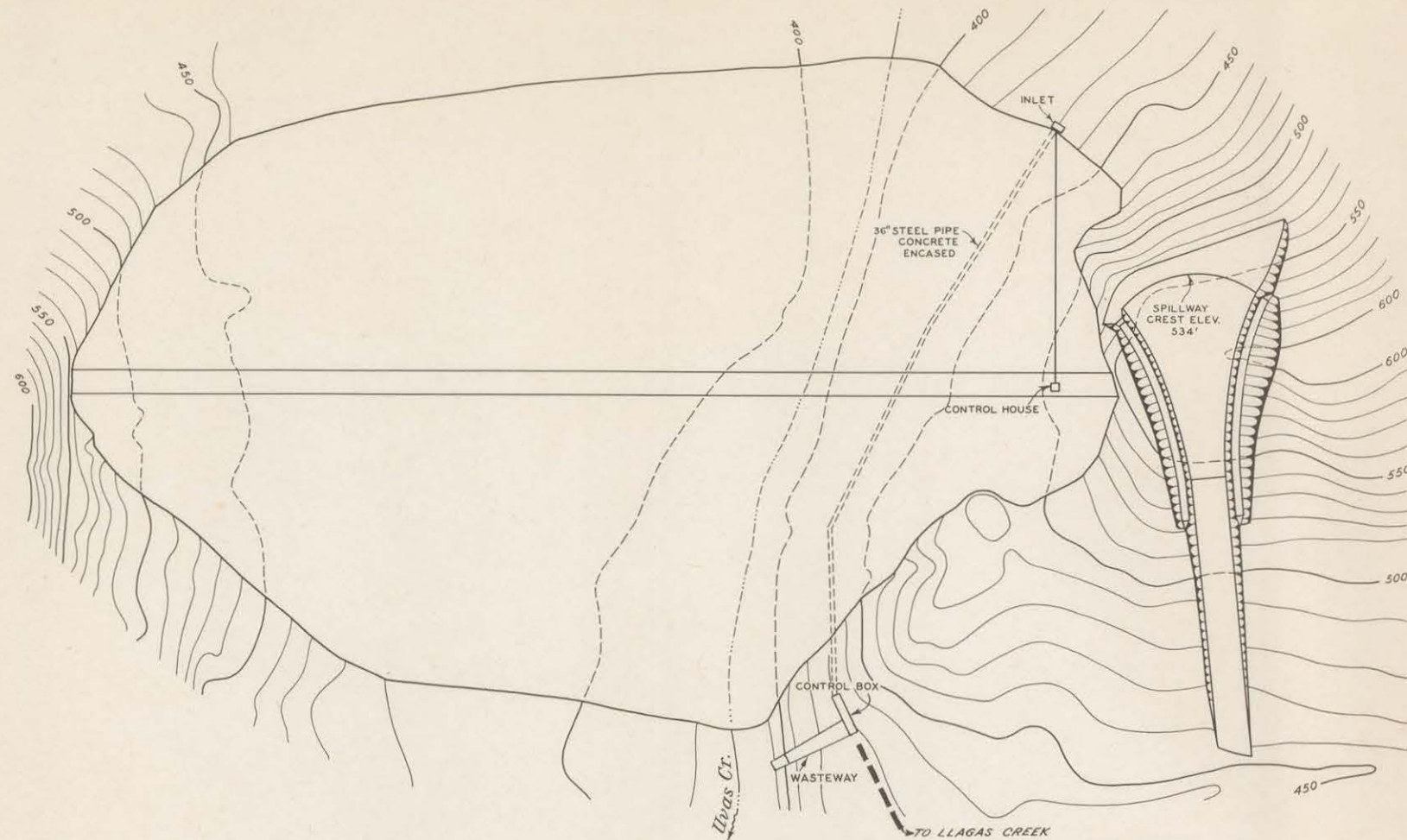


SECTION OF DAM
SCALE OF FEET
0 100 200

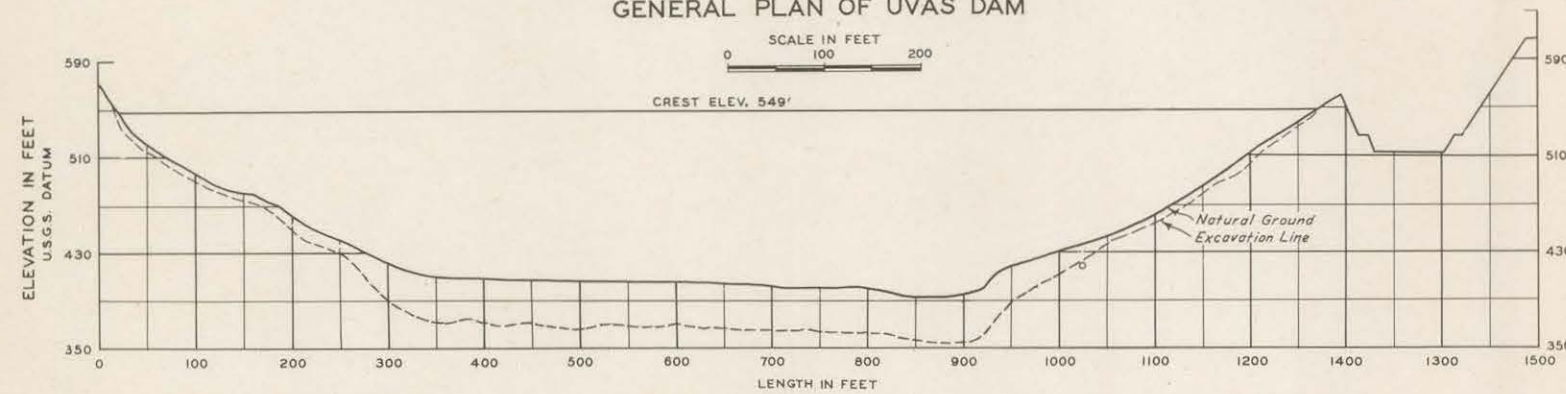


GENERAL PLAN
SCALE OF MILES
0 1 2 3 4 5 6

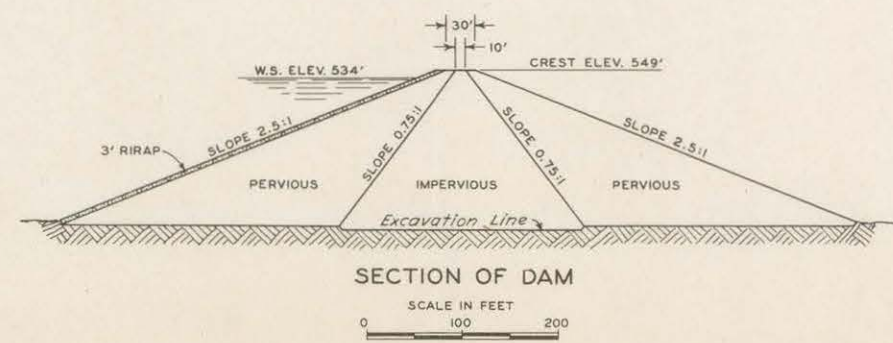
PROFILE OF CONDUIT



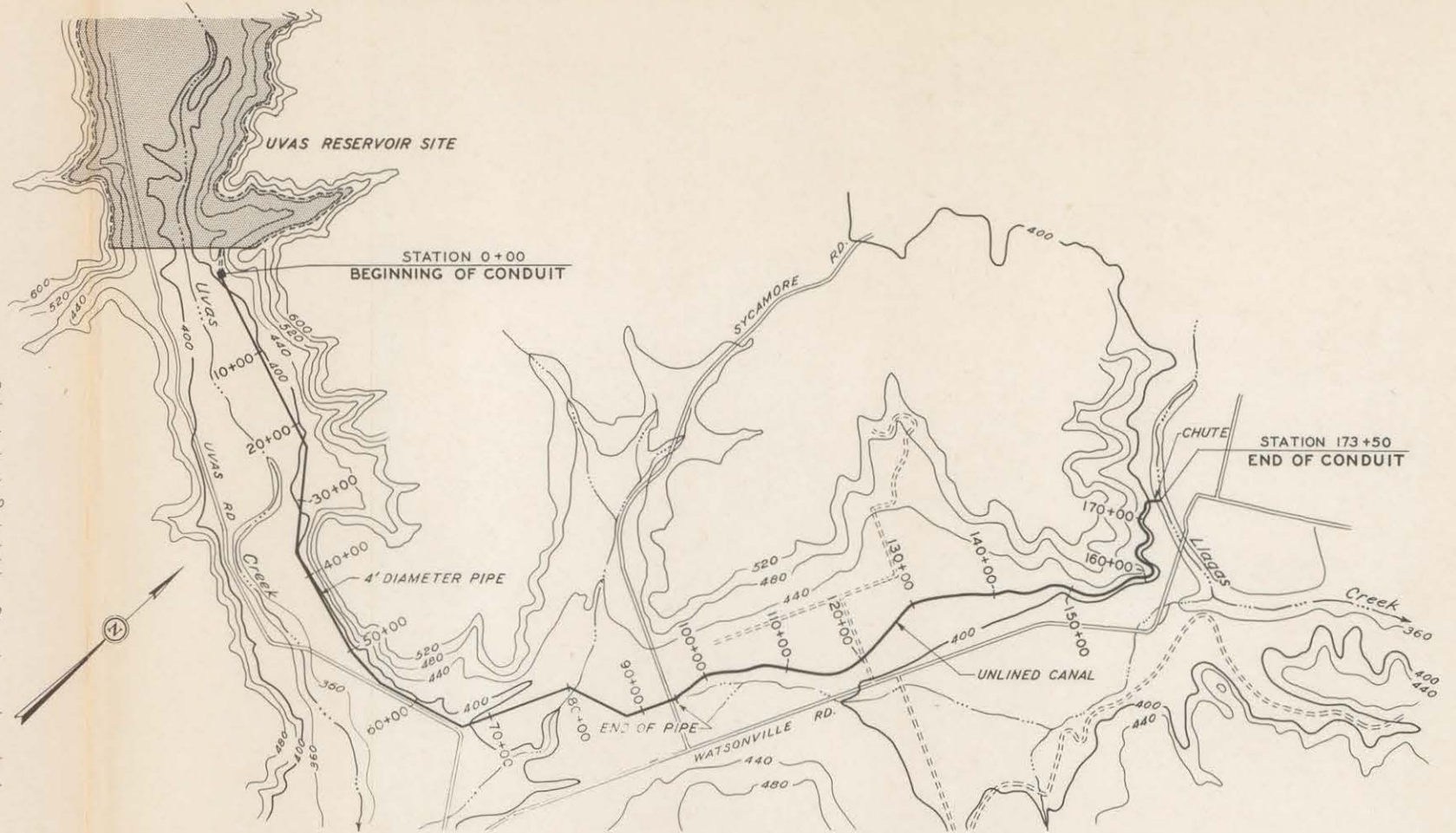
GENERAL PLAN OF UVAS DAM



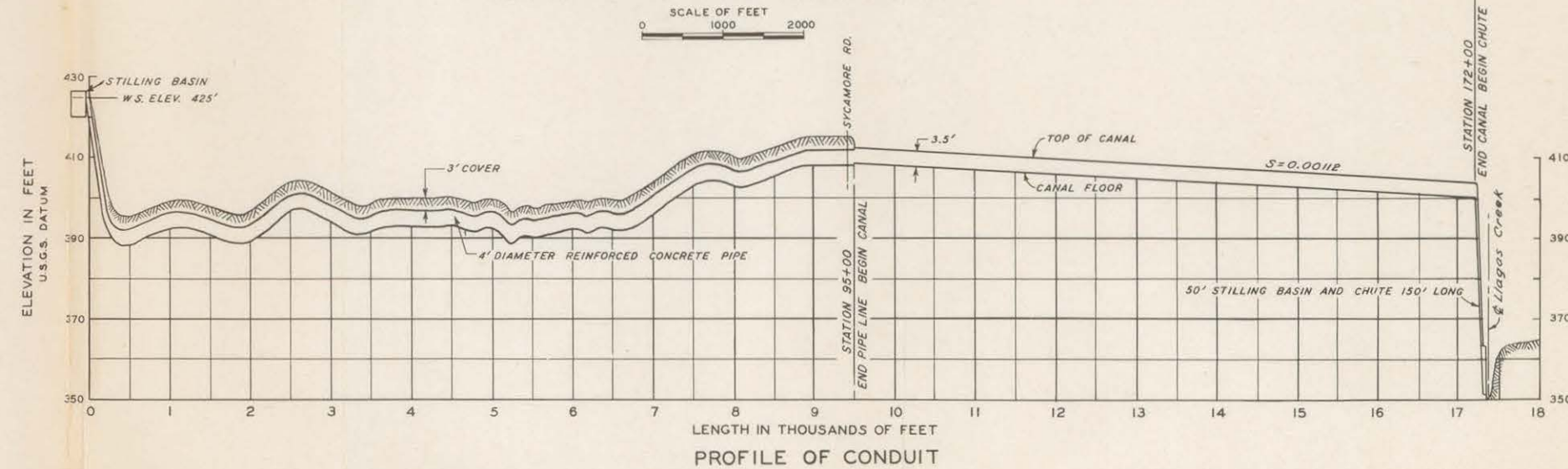
PROFILE OF DAM
LOOKING UPSTREAM



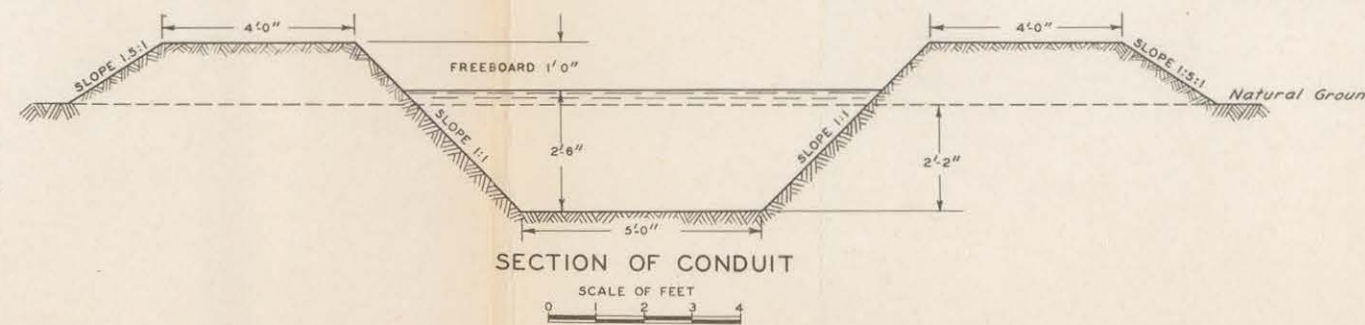
SECTION OF DAM



GENERAL PLAN OF UVAS-LLAGAS CONDUIT



PROFILE OF CONDUIT



SECTION OF CONDUIT

APPENDIX A

**AGREEMENTS AUTHORIZING INVESTIGATION
AND REPORT**

TABLE OF CONTENTS

AGREEMENTS AUTHORIZING INVESTIGATION AND REPORT

	<i>Page</i>
Agreement Between the State Water Resources Board, the County of Santa Clara, the City of San Jose, and the Department of Public Works, dated April 1, 1948-----	89
Supplemental Agreement Between the State Water Resources Board, the County of Santa Clara, the City of San Jose, and the Department of Public Works, dated February 18, 1949-----	91

**AGREEMENT BETWEEN THE STATE WATER RESOURCES BOARD, THE COUNTY OF
SANTA CLARA, THE CITY OF SAN JOSE, AND THE
DEPARTMENT OF PUBLIC WORKS**

THIS AGREEMENT, executed in quintuplicate, entered into by the State Water Resources Board, hereinafter referred to as the "Board"; the County of Santa Clara, hereinafter referred to as the "County"; the City of San Jose, hereinafter referred to as the "City"; and the Department of Public Works, acting through the agency of the State Engineer, hereinafter referred to as the "State Engineer":

WITNESSETH:

WHEREAS, by the State Water Resources Act of 1945, as amended, the Board is authorized to make investigations, studies, surveys, hold hearings, prepare plans and estimates, and make recommendations to the Legislature in regard to water development projects, including flood control plans and projects; and

WHEREAS, by said act, the State Engineer is authorized to cooperate with any county, city, State agency or public district on flood control and other water problems and when requested by any thereof may enter into a cooperative agreement to expend money in behalf of any thereof to accomplish the purposes of said act; and

WHEREAS, the County and the City desire and hereby request the Board to enter into a cooperative agreement for the making of an investigation and report on the underground water supply in the County of Santa Clara, including quality, replenishment and utilization thereof, and, if possible, a method or methods of solving the water problems involved; and

WHEREAS, the Board hereby requests the State Engineer to cooperate in making an investigation and report on the underground water supply in the County of Santa Clara, including quality, replenishment and utilization thereof, and, if possible, a method or methods of solving the water problems involved;

NOW THEREFORE, in consideration of the premises and of the several promises to be faithfully performed by each as hereinafter set forth, the Board, the County, the City, and the State Engineer do hereby mutually agree as follows:

ARTICLE I—WORK TO BE PERFORMED:

The work to be performed under this agreement shall consist of investigation and report on the underground water supply in the County of Santa Clara, including quality, replenishment and utilization thereof, and, if possible, a method or methods of solving the water problems involved.

The Board by this agreement authorizes and directs the State Engineer to cooperate by making said investigation and report and by otherwise advising and assisting in making an evaluation of present and ultimate underground water problems in the County of Santa Clara, and in formulating a solution or solutions of the water problems thereof.

During the progress of said investigation and report all maps, plans, information, data and records pertaining thereto which are in the possession of any party hereto shall be made fully available to any other party for the due and proper accomplishment of the purposes and objects hereof.

The work under this agreement shall be diligently prosecuted with the objective of completion of the investigation and report on or before December 31, 1949, or as nearly thereafter as possible.

ARTICLE II—FUNDS:

The County and the City, upon execution by them of this agreement, shall each transmit to the State Engineer the sum of Five Thousand Five Hundred Dollars (\$5,500) for deposit, subject to the approval of the Director of Finance, into the Water Resources Revolving Fund in the State Treasury, for expenditure by the State Engineer in performance of the work provided for in this agreement. Also, upon execution of this agreement by the Board, the Director of Finance will be requested to approve the transfer of the sum of Eleven Thousand Dollars (\$11,000) from funds appropriated for the support of the Board by the Budget Act of 1947, for expenditure by the State Engineer in performance of the work provided for in this agreement and the State Controller will be requested to make such transfer.

If the Director of Finance, within thirty (30) days after receipt by the State Engineer of said Eleven Thousand Dollars (\$11,000) from the County and the City, shall not have approved the deposit thereof into said Water Resources Revolving Fund, together with the transfer of the sum of Eleven Thousand Dollars (\$11,000) from funds appropriated for the support of the Board by the Budget Act of 1947, for expenditure by the State Engineer in performance of the work provided for in this agreement, said sums contributed by the County and the City shall be returned to them by the State Engineer.

It is understood by and between the parties hereto that the sum of Twenty-two Thousand Dollars (\$22,000) to be made available as hereinbefore pro-

vided is adequate to perform approximately half of the above specified work and it is the intention of the County and of the City to each make a further sum of Five Thousand Five Hundred Dollars (\$5,500) available at the commencement of the second year of said investigation which will be subject to a matching or contribution in a sum of Eleven Thousand Dollars (\$11,000) by the Board for the completion of said investigation and report.

The Board and the State Engineer shall under no circumstances be obligated to expend for or on account of the work provided for under this agreement any amount in excess of the sum of Twenty-two Thousand Dollars (\$22,000) as made available hereunder and when said sum is exhausted, the Board and the State Engineer may discontinue the work provided for in this agreement and shall not be liable or responsible for the resumption and completion thereof until further sums as specified in the preceding paragraph are made available.

Upon completion of and final payment for the work provided for in this agreement, the State Engineer

shall furnish to the Board, and to the County, and to the City, a statement of all expenditures made under this agreement. One-half of the total amount of all said expenditures shall be deducted from the sum advanced from funds appropriated to said Board, and one-fourth of the total amount of all said expenditures shall be deducted from each sum advanced by the County and by the City and any balance which may remain shall be returned to the Board, to the County, and to the City, on the basis of one-half to the Board, one-fourth to the County and one-fourth to the City.

ARTICLE III—EFFECTIVE DATE

This agreement shall become effective immediately upon its execution by all the parties hereto.

IN WITNESS WHEREOF, the parties hereunto have affixed their signatures, the County of Santa Clara on the 26 day of January, 1948, the City of San Jose on the 26 day of January, 1948, the Board on the 1st day of April, 1948 and the State Engineer on the 31 day of March, 1948.

Approval Recommended:

/s/ SPENCER BURROUGHS
Principal Attorney
Division of Water Resources

Approved as to Form:

/s/ HOWARD W. CAMPEN
County Counsel
County of Santa Clara

/s/ ROBERT E. CASSIN
City Attorney
City of San Jose

Approved:

/s/ JAMES S. DEAN
Director of Finance

Approved as to Legality:

/s/ C. C. CARLETON
Chief Attorney
Department of Public Works

COUNTY OF SANTA CLARA

By /s/ E. O. WOOL
Chairman, Board of Supervisors

Attest: ALBERT J. NEWLIN, Clerk

By /s/ RICHARD OLSON
Deputy Clerk, Board of Supervisors

[SEAL]

CITY OF SAN JOSE

By /s/ ALBERT J. RUFFO
Mayor

Attest:

/s/ DOROTHY COVILL
City Clerk

[SEAL]

STATE WATER RESOURCES BOARD

By /s/ ROYAL MILLER
Chairman

DEPARTMENT OF PUBLIC WORKS STATE OF CALIFORNIA

C. H. PURCELL
Director of Public Works

By /s/ A. H. HENDERSON
Deputy Director

EDWARD HYATT, State Engineer

By /s/ A. D. EDMONSTON
Assistant State Engineer

**SUPPLEMENTAL AGREEMENT BETWEEN THE STATE WATER RESOURCES BOARD, THE
COUNTY OF SANTA CLARA, THE CITY OF SAN JOSE, AND
THE DEPARTMENT OF PUBLIC WORKS**

THIS AGREEMENT, executed in quintuplicate, entered into by the State Water Resources Board, hereinafter referred to as the "Board"; the County of Santa Clara, hereinafter referred to as the "County"; the City of San Jose, hereinafter referred to as the "City"; and the Department of Public Works of the State of California, acting through the agency of the State Engineer, hereinafter referred to as the "State Engineer":

WITNESSETH:

WHEREAS, by agreement heretofore entered into by and between the parties hereto, executed by the County on the 26th day of January, 1948, by the City on the 26th day of January, 1948, by the Board on the 1st day of April, 1948, and by the State Engineer on the 31st day of March, 1948, the making by the State Engineer of an investigation and report on the underground water supply in the County of Santa Clara, including quality, replenishment and utilization thereof and, if possible, a method or methods of solving the problems involved, was provided for; and

WHEREAS, it was the expressed intention in said agreement that at the commencement of the second year of said investigation said County and City would each make available a further sum of Five Thousand Five Hundred Dollars (\$5,500) subject to a matching or contribution in equal amount by the Board for the completion of said investigation and report; and

WHEREAS, said additional funds are required to complete said investigation and report, and it is the desire of the parties hereto that an additional sum of Twenty-two Thousand Dollars (\$22,000) shall be provided, Five Thousand Five Hundred Dollars (\$5,500) each by the County and City and Eleven Thousand Dollars (\$11,000) by the Board;

NOW THEREFORE, in consideration of the premises and of the several promises to be faithfully performed by each as hereinafter set forth, the Board, the County, the City, and the State Engineer do hereby mutually agree as follows:

1. The County and City each, upon execution by it of this agreement, shall transmit to the State Engineer the sum of Five Thousand Five Hundred Dollars (\$5,500) for deposit, subject to the approval of the Director of Finance, into the Water Resources Revolving Fund in the State Treasury for expenditure by the State Engineer in continuing performance of the work provided for in said prior agreement to which this agreement is supplemental.

2. Upon execution of this agreement by the Board, the Director of Finance will be requested to approve the transfer of the sum of Eleven Thousand Dollars (\$11,000) from funds appropriated to the Board by Item 335 of the Budget Act of 1948 for expenditure by the State Engineer in continuing performance of the work provided for in said prior agreement to which this agreement is supplemental, and the State Controller will be requested to make such transfer.

3. The Board and the State Engineer shall under no circumstances be obligated to expend for or on account of the work provided for in said prior agreement to which this agreement is supplemental any amount in excess of the sum of Forty-four Thousand Dollars (\$44,000) as made available under said prior agreement and this supplemental agreement and if funds are exhausted before completion of said work the Board and the State Engineer may discontinue said work and shall not be liable or responsible for the completion thereof.

4. In so far as consistent herewith and to the extent adaptable hereto, all of the terms and provisions of said prior agreement to which this agreement is supplemental are hereby made applicable to this agreement and are hereby confirmed, ratified, and continued in effect.

5. This agreement shall become effective immediately upon its execution by all of the parties hereto, and its approval by the Director of Finance.

IN WITNESS WHEREOF, the parties hereunto have affixed their signatures, the County of Santa Clara on the 24th day of January, 1949, the City of San Jose on the 1st day of February, 1949, the Board on the 17th day of February, 1949, and the State Engineer on the 18th day of February, 1949.

SANTA CLARA VALLEY INVESTIGATION

Approved as to form:

/s/ HARRY C. NAIL, JR.
Asst. County Counsel,
County of Santa Clara

/s/ ROBERT E. CASSIN
City Attorney,
City of San Jose

Approval Recommended:

/s/ HENRY HOLSINGER
Principal Attorney
Division of Water Resources

Approval Recommended:

/s/ C. C. CARLETON
Chief Attorney
Department of Public Works

Approved:

/s/ JAMES S. DEAN
Director of Finance

COUNTY OF SANTA CLARA

By /s/ A. W. BROWN
Chairman, Board of Supervisors

ALBERT J. NEWLIN, County Clerk

By /s/ RICHARD OLSON, Deputy Clerk,
Board of Supervisors

[SEAL]

CITY OF SAN JOSE

By /s/ FRED WATSON
Mayor

/s/ DOROTHY COVILL
City Clerk

[SEAL]

STATE WATER RESOURCES BOARD

By /s/ C. A. GRIFFITH
Chairman

DEPARTMENT OF PUBLIC WORKS
STATE OF CALIFORNIA

By C. H. PURCELL
Director of Public Works

By /s/ FRANK B. DURKEE
Deputy Director

[SEAL]

/s/ EDWARD HYATT
State Engineer

R.S. Form	J.W.M. Budget	Value	Descript.
--------------	------------------	-------	-----------

DEPARTMENT OF FINANCE

APPROVED

Feb. 24, 1949

James S. Dean, Director

APPENDIX B

BIBLIOGRAPHY OF PRIOR REPORTS

Reports on prior investigations, containing information pertinent to the evaluation of water problems in Santa Clara County, which have been reviewed in connection with the current investigation, are listed in the following bibliography.

Additional references of the geology of Santa Clara County are included in Appendix C.

APPENDIX B

BIBLIOGRAPHY OF PRIOR REPORTS

- Blackie, E. E., and Wood, H. "Report to the Honorable Board of Directors of the South Santa Clara Valley Water Conservation District on Water Supply and Well Replenishment Project." Project Report No. 1. January, 1939.
- "Report to the Honorable Board of Directors of the South Santa Clara Valley Water Conservation District on Llagas Creek Storage." Project Report No. 2. December, 1940.
- "Report to the Honorable Board of Directors of the South Santa Clara Valley Water Conservation District on Llagas Creek Flow, 1941-42." Project Report No. 3. November, 1942.
- "Report to the Honorable Board of Directors of the South Santa Clara Valley Water Conservation District on Llagas Creek Flow, 1942-1943." Project Report No. 4. October, 1943.
- "Report to the Honorable Board of Directors of the South Santa Clara Valley Water Conservation District on Llagas Creek Flow, 1943-1944." Project Report No. 5. January, 1945.
- "Report to the Honorable Board of Directors of the South Santa Clara Valley Water Conservation District on Llagas Creek Flow, 1944-45." Project Report No. 6. November, 1945.
- "Report to the Honorable Board of Directors of the South Santa Clara Valley Water Conservation District on Llagas Creek Flow, 1945-1946." Project Report No. 7. November, 1946.
- "Report to the Honorable Board of Directors of the South Santa Clara Valley Water Conservation District on Llagas Creek Well Replenishment Project." Project Report No. 8. June, 1947.
- "Report to the Honorable Board of Directors of the South Santa Clara Valley Water Conservation District on Llagas Creek Flow, 1946-47." Project Report No. 9. November, 1947.
- "Report to the Honorable Board of Directors of the South Santa Clara Valley Water Conservation District on Llagas Creek Flow, 1947-48." Project Report No. 10. October, 1948.
- "Report to the Honorable Board of Directors of the South Santa Clara Valley Water Conservation District on Llagas Creek Flow, 1948-49." Project Report No. 11. March, 1950.
- "Report to the Honorable Board of Directors of the South Santa Clara Valley Water Conservation District on Llagas Creek Flow, 1949-50." Project Report No. 12. October, 1950.
- "Report to the Honorable Board of Directors of the South Santa Clara Valley Water Conservation District on Llagas Creek Flow, 1950-51." Project Report No. 13. November, 1951.
- "Report to the Honorable Board of Directors of the South Santa Clara Valley Water Conservation District on Llagas Creek and Uvas Creek Well Replenishment Project." Project Report No. 14. January, 1952.
- "Report to the Honorable Board of Directors of the South Santa Clara Valley Water Conservation District on Uvas Creek Dam, Reservoir, Conduit and Well Replenishment Project Proposed to be Constructed Jointly with Santa Clara Valley Water Conservation District and on Proposed Llagas Creek Dam, Reservoir and Well Replenishment Project." Project Report No. 15. March, 1953.
- Blaney, H. F., and Criddle, W. D. "A Method of Estimating Water Requirements in Irrigated Areas From Climatological Data." United States Department of Agriculture, Soil Conservation Service, Division of Irrigation. 1945.
- California State Department of Public Works, Division of Water Resources. "Santa Clara Investigation." Bulletin No. 42. 1933.
- "South Coastal Basin Investigation, Geology and Ground Water Storage Capacity of Valley Fill." Bulletin No. 45. 1934.
- "Report of Referee, City of Pasadena v. City of Alhambra, et al." Case No. Pasadena C-1323, Superior Court Los Angeles County. June, 1943.
- "Feasibility of the Reclamation and Conveyance of Sewage from San Francisco, Peninsula Cities and Communities, and San Jose, for Use in Santa Clara County." April, 1951.
- "Program for Financing and Constructing the Feather River Project as the Initial Unit of The California Water Plan." February, 1955.
- California State Water Project Authority. "Feasibility of Construction by the State of Barriers in the San Francisco Bay System." March, 1955.
- California State Water Resources Board. "Report on Feasibility of Feather River Project and Sacramento-San Joaquin Delta Diversion Projects Proposed as Features of The California Water Plan." May, 1951.
- "Water Resources of California." Bulletin No. 1, 1951.
- Clark, W. O. "Ground Water for Irrigation in the Morgan Hill Area, California." Contributions to the Hydrology of the United States, 1916. United States Department of the Interior, Geological Survey. Water-Supply Paper 400. 1917.
- "Ground Water in the Santa Clara Valley, California." United States Department of the Interior, Geological Survey. Water-Supply Paper 519. 1924.
- Fortier, S. "Irrigation in Santa Clara Valley, California." United States Department of Agriculture, Office of Experiment Stations, in cooperation with State of California. Bulletin 158, Separate No. 2, 1905.
- Holmes, L. C., and Nelson, J. W. "Reconnaissance Soil Survey of the San Francisco Bay Region, California." United States Department of Agriculture, Bureau of Soils, in cooperation with the University of California, Agricultural Experiment Station. 1917.
- Hunt, G. W. "Description and Results of Operation of the Santa Clara Valley Water Conservation District's Project." American Geophysical Union, Transactions of 1940, Part I. July, 1940.
- "Report to the Board of Directors of Santa Clara Valley Water Conservation District on Proposed Lexington Dam and Water Conservation Works." August, 1947.
- "Report to the Honorable Board of Directors of the Santa Clara Valley Water Conservation District on Proposed Coyote Dam No. 2." April, 1949.
- "Report to the Honorable Board of Directors of the Santa Clara Valley Water Conservation District on Proposed Cross-Valley Canals." July, 1952.
- "Supplement to Report to the Honorable Board of Directors of the Santa Clara Valley Water Conservation District on Proposed Lexington Dam and Water Conservation Works." July, 1952.

- Lawson, A. C. "Geologic Atlas of the United States, San Francisco, California." United States Department of the Interior, Geological Survey. Folio No. 193. 1914.
- San Jose Chamber of Commerce. "7 Sources of Water Supply for Santa Clara County." June, 1949.
- Santa Clara County Engineering Department. "Preliminary Report on the Guadalupe Creek and Tributaries, Santa Clara County, California, for Flood Control and Runoff." 1944.
- Santa Clara County Planning Commission. "Flood Problems in Santa Clara County." Monograph No. 3. 1952.
- Santa Clara Valley Water Conservation District, Board of Directors. "Official Statement on Lexington Dam." September, 1947.
- "Official Statement on I Lexington Dam, II Cross-Valley Canals." September, 1952.
- Tibbetts, F. H., and Kieffer, S. E. "Report to Santa Clara Valley Water Conservation District Committee on Santa Clara Valley Water Conservation Project." March, 1921.
- Tibbetts, F. H. "Report on Waste Water Salvage Project to Board of Directors, Santa Clara Valley Water Conservation District, San Jose, California." October, 1931.
- "Supplemental Report on Completion of the 1934 Well Replenishment Project Including 1931 Waste Water Salvage Project." Project Report No. 34. March, 1936.
- "Water-Conservation Project in Santa Clara County." Transactions American Geophysical Union, Seventeenth Annual Meeting, Part II. July, 1936.
- Tolman, C. F., and Poland, J. F. "Ground-Water, Salt-Water Infiltration, and Ground-Surface Recession in Santa Clara Valley, Santa Clara County, California." American Geophysical Union, Transactions of 1940, Part I. July, 1940.
- United States Department of Agriculture, Office of Experiment Stations. "Irrigation Resources of California and Their Utilization." Bulletin 254. 1913.
- Weir, W. W., and Storie, R. E. "Soils of Santa Clara County, California." University of California, Agricultural Experiment Station, Division of Soils. February, 1947.

APPENDIX C
GEOLOGY OF THE SANTA CLARA VALLEY

APPENDIX C

GEOLOGY OF THE SANTA CLARA VALLEY

	<i>Page</i>
Introduction	99
Previous Work and Acknowledgments	99
Scope of Investigation	99
Geologic Formations	99
Nonwater-bearing Group	99
Jurassic System	99
Cretaceous System	99
Eocene Series	100
Oligocene Series	100
Miocene Series	100
Pliocene Series	100
Water-bearing Group	100
Plio-Pleistocene Series	100
Upper Quaternary Series	102
Geologic Structure	103
Folds	103
Faults	104
Geologic History and	
Origin of the Present Topography	104

PLATES

C-1. Areal Geology, 1955	following page 106
C-2. Index Map	“ “ “
C-3. Columnar Sections—Santa Clara County	“ “ “
C-4. Geologic Sections, 1955	“ “ “

GEOLOGY OF THE SANTA CLARA VALLEY

INTRODUCTION

The area discussed in this appendix lies entirely within Santa Clara County, but does not include the easternmost part of the county. The term "Santa Clara Valley" as used herein refers only to the valley floor within the county. "North Santa Clara Valley" refers to the valley floor north of the Lower Gorge of Coyote Creek, near the town of Coyote. The term "South Santa Clara Valley" refers to the valley floor south of the Lower Gorge. The southern valley, then, includes some of the area which is drained northward by Coyote Creek.

Previous Work and Acknowledgments

Geologic mapping of nearly all of the Santa Clara Valley and its environs was completed in the five years preceding 1950. The results of this mapping have been incorporated in Plate C-1, "Areal Geology," the geologic map. The various sources of the mapping and the areas covered by each source are shown in Plate C-2, "Index Map," which also shows the quadrangles covering the Santa Clara Valley and vicinity. Appreciation is expressed to all whose mapping has been used. Particular appreciation is expressed to Olaf P. Jenkins and the California Division of Mines for their aid in the compilation of the geologic map for this appendix, and to Edgar H. Bailey of the United States Geological Survey and Robert Ortalda for their helpful suggestions during the preparation of the appendix.

Papers to which reference is made in the text of this appendix are as follows:

- Blackwelder, Elliot, "A Mastodon Skeleton Near San Francisco Bay," Washington Academy Science Journal 19, 1929.
- Branner, J. C., Newsom, J. F., and Arnold, Ralph, "Santa Cruz Folio, California," Geol. Atlas of the United States, Folio 163, U. S. Geological Survey, 1909.
- Crittenden, Max, "Geology of the San Jose and Mount Hamilton Quadrangles, California," California Division of Mines, Bulletin 157, 1951.
- Taliaferro, N. L., "Geologic History and Structure of the Central Coast Ranges of California," California Division of Mines, Bulletin 118, 1943.

Scope of Investigation

This appendix has been prepared to provide a geologic basis for certain studies made and reported in the accompanying bulletin. Descriptions of the water-bearing and nonwater-bearing sediments are included herein, with emphasis placed on the former and on the relationships between the two series. For purposes of ground water studies, the most important part of the geology is the description of the water-bearing sediments. Other aspects of geology are briefly considered

in order to complete the geologic description of the valley.

The areal distribution of the geologic formations of the Santa Clara Valley region is shown on the geologic map (Plate C-1). The columnar sections (Plate C-3) describe in tabular form the formations throughout the region, and the cross sections (Plate C-4) show depth relations in various areas.

GEOLOGIC FORMATIONS

The rocks of the Santa Clara Valley region are mainly marine and fresh water sediments, ranging in age from upper Jurassic to Recent. For ground water studies, the rocks of the region may be divided into two groups, the water-bearing and the nonwater-bearing.

Nonwater-bearing Group

The nonwater-bearing group consists of those rocks which are relatively unimportant in the ground water study because they do not generally yield economically important quantities of water, although they do form the basement underlying the water-bearing sediments. The nonwater-bearing group is called bedrock in this bulletin.

Jurassic System. Rocks of upper Jurassic age include the Franciscan and Knoxville formations, which are mapped together on Plate C-1.

The Franciscan formation consists of marine sediments, slightly altered igneous rocks, serpentine, and small pods of metamorphosed sediments. The sediments consist of arkosic sandstones, dark shales, limestones, cherts, and a few scattered lenses of conglomerate. Interbedded with these sediments are basalts, basaltic tuffs, and basaltic agglomerates, all slightly altered to greenstones. All these sediments and igneous rocks have been intruded by andesite porphyry, diorite, and serpentine.

The Knoxville formation consists of marine sandstones, shales, and a few conglomerates. Rocks proven by fossil evidence to be Knoxville are of limited extent and generally have not been differentiated from the Franciscan rocks in studies of this area.

The only important conduits for water in the upper Jurassic rocks are faults and fracture systems. Springs are common along faults in these rocks, and some wells produce up to 100 gallons per minute from faults. The production of most such fracture system wells falls off or ceases in the dry season.

Cretaceous System. Rocks of Cretaceous age in the Santa Clara Valley region are marine shales, sandstones, and conglomerates. The formation names of

these rocks are shown on the columnar sections, Plate C-3.

Only minor quantities of water are produced from Cretaceous rocks in most areas, the water obtained generally coming from fractures as in the case of the Jurassic rocks. There are two known exceptions to this general rule, however. On the east edge of North Santa Clara Valley, east and northeast of Evergreen, the Cretaceous rocks are mostly conglomeratic. The unweathered conglomerates have a calcite matrix, which, upon weathering, becomes permeable, and the weathered conglomerate thereby furnishes some water to domestic wells. Some of the unweathered sandstone in the Santa Teresa Hills is also permeable. Certain wells drilled in this sandstone yield 15 to 40 gallons per minute.

The sandstones and conglomerates in other areas are usually less permeable. The shales yield practically no water.

Eocene Series. Rocks of Eocene age outcrop in only three relatively small areas in the Santa Clara Valley region, as shown on Plate C-1. They are marine shales and sandstones whose age has been proven by fossil identification and correlation. These rocks have little hydrologic importance.

Oligocene Series. Rocks of Oligocene age outcrop only in the Santa Cruz Mountains near the western border of Santa Clara County. These rocks are marine sandstones and shales and have no hydrologic significance.

Miocene Series. The Miocene series of this region consists of both sedimentary and igneous rocks. The sediments are fossiliferous marine sandstones, shales, claystones, siliceous shales, and gravels. The igneous rocks consist of basalts, often vesicular, basaltic agglomerates, and rhyolitic and basic tuffs, many of which are water-deposited. Fossils collected in the Palo Alto area in 1948, and identified with the aid of Dr. Myra Keen of Stanford University, show that most of the rocks called Pliocene (Purisima formation) by Branner, Newsom, and Arnold (1909), are actually Miocene.

Water wells have been drilled into rocks of Miocene age in several areas. The most successful wells derive their water from fractures in basalt and from gravels associated with the basalt flows. Certain of these wells yield up to 60 gallons per minute for domestic purposes. Some of the springs which originate in sandstone yield up to 35 gallons per minute.

Pliocene Series. Rocks of Pliocene age outcrop only in the San Juan Bautista and San Jose quadrangles. The names of the Pliocene formations are shown on the columnar sections, Plate C-3. The Pliocene series consists of marine conglomerates and sandstones, with some lenses of marl and sandy marl, fresh

water sandstones, sands, gravels, and conglomerates. Both marine and fresh water fossils are found in this series.

Pliocene rocks, where exposed, appear to be fairly permeable, but since these sediments are limited in extent within the county, they are not believed to have much hydrologic importance.

The Plio-Pleistocene sediments are difficult to distinguish from older continental Pliocene sediments. In the San Juan Bautista and Hollister quadrangles, south of Santa Clara County, the contact between these sediments is gradational and obscure. Fossil evidence is lacking at the present time, and terminology is in a state of change. In this appendix, the term "Plio-Pleistocene" will refer to sediments thought to be of late Pliocene and early Pleistocene age, and the term "Pliocene" will refer to sediments of early and middle Pliocene age.

Water-bearing Group

Plio-Pleistocene Series. The Plio-Pleistocene series is significant with respect to the ground water hydrology of the Santa Clara Valley. Deep wells, especially in the Los Altos, Cupertino, and Los Gatos areas, derive much of their water from this series, the overlying upper Quaternary sediments being generally less than 400 feet thick.

The formations of the Plio-Pleistocene series outcropping in the Santa Clara Valley include the Santa Clara, Packwood, and San Benito formations. The probable age relations involving these formations are shown in the columnar sections, Plate C-3, and their areal extent is shown on the geologic map, Plate C-1.

The Plio-Pleistocene series consists mostly of fresh-water gravels, silts, and clays, all of which are common in outcrops. Well-bedded gravels, sands, marls, and vitric tuff layers with interbedded olivine basalt flows are present near the base of the series in the Morgan Hill-Gilroy area. Approximately two miles west of Stanford University, basal sand beds are about eight feet thick and contain a distinctive marine molluscan fauna which indicates that they are the equivalent of part of the Merced formation in San Mateo and San Francisco Counties (Myra A. Keen, oral communication, 1947). About five miles west of Stanford University, the basal beds consist of poorly bedded sands about 50 feet thick, which contain small, interbedded, lenticular coal or lignite seams up to two inches thick. Here the sands grade upward into the thick gravels which make up most of the series.

Depths of gravel and clay overlying the basal beds vary from 1,000 to 4,000 feet. Decrease in pebble size and proportionate increase in clay toward the central part of the northern valley, as well as the nature of the deposits, indicates that the bulk of the Plio-Pleistocene sediments were deposited as great alluvial fans.

Gravels of various sizes comprise about one-third of the Plio-Pleistocene series. In general, the coarsest gravels, and the largest proportion of gravel in the series, occur around the edges of the Santa Clara Valley. However, this does not hold true in the southern valley, where the Plio-Pleistocene series outcrops only along the east side of the valley. The gravels include sandstone and shale pebbles from older formations; serpentine and metamorphic pebbles; igneous pebbles of basaltic, andesitic, gabbroic, and granitic nature; and boulders and pebbles originally derived from well-cemented conglomerates.

The individual beds of gravels are very irregular and lenticular. Groups of these can often be correlated from place to place, but correlation of individual beds is generally impossible. The clean gravels may grade into any combination of gravels, sands, and clays, which in turn may eventually pinch out or grade into either sands or clays alone. The term "gravel" as used in this appendix does not imply any specified degree of rounding of the constituent fragments. The term "uncemented conglomerate" would perhaps be more suitable in most areas, although other stream and lake deposits show many of the same characteristics as the alluvial fan deposits.

The sands of the Plio-Pleistocene series, in general, are lenticular, medium-grained, and consist mostly of subangular grains of quartz and feldspar. Most of the sands in the outcrops are cross-bedded, but the individual layers showing cross-bedding are usually small, one-half to six inches in thickness, and irregular.

The term "clay" as used in this appendix does not refer to the pure mineral clays which the word technically denotes, but instead refers to all strata which are not permeable due to their high content of fine particles. Nearly all of the clays described by the drillers contain only a relatively small proportion of true clay, the remainder of the material being silt, sand, or gravel.

Clays in the Plio-Pleistocene series fall into three broad genetic classifications. The two most common of these are stream- or flood-deposited clays, and clays which have been formed as the result of weathering. The other type of clay is marine- or tideflat-deposited clay. Clay of this latter type may be present at depths greater than 800 feet in the vicinity of San Jose in the Plio-Pleistocene sediments.

The depositional clays may be blue, yellow, or brown, the last two colors being most common. Some of the yellow clays may represent oxidized blue clays.

The clays which are the result of weathering are brown, red, and yellow. They can be differentiated from the depositional clays by the pitted surface of the enclosed sand grains and pebbles. Most of the "cement gravels" and "tight gravels" of the drillers are actually weathered gravels, sands, or gravelly silts. The most prominent layer of weathered materials occurs at a depth of about 800 feet in the middle of the

northern part of the Santa Clara Valley and outcrops in the Cupertino-Los Gatos area. This layer is from 100 to 400 feet thick.

Calcium and magnesium carbonate deposits are found in a few localities near the base of the Plio-Pleistocene series. Most of these represent subsurface chemical deposits. They are generally very impure, discontinuous, and have no bedding. A few of the deposits are fairly pure, and these may represent marls and limestones chemically deposited in fresh-water lakes. In outcrops these carbonate deposits are thin (two feet or less) and grade laterally into sands and gravels within short distances. Some of the marls resemble tufa deposits.

On the northeast side of the southern part of the Santa Clara Valley there are olivine basalts and olivine basalt agglomerates interbedded with the Plio-Pleistocene sediments. Slight baking of the sediments underlying the basaltic flows can usually be observed, and the tops of the flows are highly vesicular. These basalts have been tightly folded along with the sediments and are now thoroughly fractured.

The Plio-Pleistocene series is folded and faulted where exposed. In the sections between the larger faults the sediments often dip from three to ten degrees, this probably being approximately the original angle of deposition. Near the larger faults, which are generally more than five miles in length, dips vary upward from 30 degrees, and beds are even overturned in a few localities. Therefore, it is apparent that the folding has been intensified by faulting.

Little can be said about the structure of the Plio-Pleistocene rocks where concealed beneath upper Quaternary sediments. The series has undoubtedly been faulted, tilted, or folded in the areas where covered, but definite location of structures cannot yet be made owing to the lack of deep well logs.

It is probable that the base of the sediments here called Plio-Pleistocene is upper Pliocene in age in the southern part of the area, becoming progressively younger to the northwest. The top of the series has been removed by erosion in most areas of outcrop. Where present, it is probably middle Pleistocene in age, predating the extensive middle Pleistocene Coast Range disturbances.

The Plio-Pleistocene series is not now an important source of water to the Santa Clara Valley. Wells around the edges of the northern valley floor and in the foothills where these sediments outcrop derive much water from them, however. The best aquifers in the series are gravels. The weathered sediments mentioned previously yield only small amounts of water to wells. Around the edges of the valley, many wells penetrate water-bearing gravels below this weathered layer. In the central portion of the northern valley, a few wells have penetrated the weathered layer, but these have not produced as much additional water as might be expected.

The Cupertino-Monte Vista area has many wells which yielded notable amounts of water when they were first drilled two to twenty years ago, but which since have gradually fallen in production and have finally been abandoned. This is probably due to the fact that the gravels of the Plio-Pleistocene series in this area pinch out toward San Francisco Bay. The rate of recharge of the gravels is apparently much slower than the rate of pumping. Some of the gravel strata encountered may be effectively sealed off by clays from any recharge area.

The fractured basalts interbedded with the Plio-Pleistocene series in South Santa Clara Valley are permeable, and springs are very abundant in and around the basalts.

Upper Quaternary Series. The upper Quaternary series is here defined as sediments of Recent and late Pleistocene age which have been deposited after the main period of middle Pleistocene mountain building. The upper Quaternary series is the chief water-bearing formation in the Santa Clara Valley. Practically all of the main and side valley floors are covered with at least 50 feet of Recent and upper Pleistocene sediments. In the main valley, the sediments probably reach a thickness of 1,000 feet or more. The lower limit is usually very difficult to determine from well logs, because lithological differences with the underlying Plio-Pleistocene series are not great.

Areas of upper Quaternary deposits are shown on Plate C-1 by the symbol Q. Three genetic types of sediments are present. These are (1) alluvial fan deposits (most common), (2) flood plain deposits, and (3) tideland and marine deposits. The alluvial fan deposits occur chiefly around the edges of the valley. The Coyote cone is an alluvial fan which extends across the valley to Morgan Hill. In the northern valley, the alluvial fans interfinger with the tideland and flood plain deposits, which are the predominant sediments in the central part of the valley.

The upper Quaternary sediments consist of gravels, clays, sands, and various mixtures of these types. Numerous redwood logs are reported from wells at depths of between 35 feet and 400 feet. It is probable that the maximum thickness of the upper Quaternary fill is about 1,000 feet in the San Jose-Alviso area. The part of this thickness composed of sediments which are actually Recent in age is unknown.

It should be remembered in the following discussion that strata of pure clay, sand, or gravel greater than one foot in thickness are rare. For example, what is usually termed a ten-foot gravel bed actually consists of perhaps two to twelve inches of clean gravel, the remainder being clay and gravel or sand and gravel. A thick clay bed usually consists of only one-third to two-thirds silt and clay, the rest being a mixture of these with sand and gravel.

Upper Quaternary gravels consist of rocks from all older formations. The constituent rock types include sandstones, shales, conglomerates, cherts, igneous rocks, and more rarely, metamorphic rocks. The degree of rounding generally becomes more perfect as the size increases. Most of the constituents over three inches in diameter are well rounded. Those from three inches to one-half inch in diameter are generally subrounded to subangular, and smaller fragments range from subrounded to angular, depending on their source and composition.

Upper Quaternary gravels occur most commonly as the predominant materials in the apex areas of alluvial cones, and in stream beds below temporary base levels produced by resistant rock. The areas which are highest in gravel content are the edges of the northern valley, the areas upstream and downstream from the Lower Gorge of Coyote Creek, and the Guadalupe and Alamos Creek areas near the tip of the Santa Teresa Hills. Some of the cleanest gravels in the valley occur upstream from the Lower Gorge of Coyote Creek. The gravels in the quarry pits of the southern valley show cross-bedding, lenticular bedding, and rapid changes in size and sorting, all of which are characteristic of stream deposits.

Sands of the upper Quaternary sediments are generally poorly sorted and consist principally of quartz and chert grains. They also frequently contain high percentages of feldspar and serpentine, depending on the source rocks.

The clays may be conveniently put into three genetic and two descriptive classes. The descriptive classes of the well drillers are usually yellow clays and blue clays. The "yellow" clays of the drillers include clays which are actually red, brown, and yellow. The "blue" clays of the drillers generally include blue, greenish blue, blue-gray, and gray clays. The genetic classes of clays include residual, alluvial, and marine or tideland types. Some of the surficial yellow clays are made up almost entirely of wind-blown silts (loess). Most alluvial clays, which may be either yellow or blue, were laid down as flood or pond deposits and are therefore generally lenticular. The blue clays in the Stanford University area found in wells below 300 feet are probably stream deposits consisting mostly of serpentine and its decomposition products.

The more or less continuous blue clays in the central part of the northern valley are considered to be tideland deposits. Marine fossils have been reported in these clays to depths of 300 feet at Alviso and at the Port of Redwood City in San Mateo County. These clays are the most important in the valley, since they form the impermeable, nearly horizontal barriers which confine the aquifers within the pressure zones. The black tideland deposits around the southern end of San Francisco Bay are unconsolidated equivalents of the deeper blue clays. The

latter are thickest in the central part of the northern valley, indicating that an arm of San Francisco Bay has been present there during part of Recent and upper Pleistocene time. Assuming that conditions similar to those of today existed when the deeper blue clays were deposited, their extent probably delimits the extent of former tidal lands.

In the southern part of the valley near Gilroy and the Pajaro River, lenticular beds of tule and other plant remains up to three feet in thickness have been encountered in wells. Fresh-water mollusks were found in a blue clay near Gilroy at a depth of about 350 feet during the period of this investigation. These were determined to be of the same species as those which occur in the present-day streams. These non-marine fossils indicate that the blue clays of this area are swamp or lake deposits.

The upper Quaternary sediments of the Santa Clara Valley have been deposited over a period of about 300,000 to 500,000 years. Common fossils found in wells include redwood fragments, swamp plants, and shells of mollusks. The Recent shells belong to species that still live in San Francisco Bay or in streams today.

Indian skeletons and artifacts have been found in many shell mounds, but these are seldom more than six feet beneath the surface. The only other fossil of interest was a mastodon skeleton uncovered near Redwood City in San Mateo County. The skeleton was found in undisturbed light green clay 23 feet below the surface. The mastodon was a type common in early Recent and late Pleistocene times. (Blackwelder, 1929.)

In the Hollister quadrangle (San Benito County), and in the vicinity of the town of Niles (Alameda County), there is clear evidence that Recent sediments have been faulted. These areas lie beyond the scope of this appendix, but suggest that similar disturbed sediments may also be present in the Santa Clara Valley.

Pressure areas overlain by confining blue clay strata exist in the central portion of the northern valley and the southern portion of the southern valley. In these areas, shallow water overlying the blue clay is common, but is not generally used as a source of water. Elsewhere in the valley, free ground water conditions occur.

Most of the aquifers from which pumping occurs in the upper Quaternary sediments are composed of gravels. Sand aquifers are also present, but well casings are seldom perforated in these zones, since sands would run into the wells rapidly, screens not commonly being used by drillers in this area. Gravel envelope wells often eliminate sanding and caving troubles, and such wells are usually among the highest producers.

The blue clays of the northern valley have yielded an estimated 4,000 acre-feet of water per year to wells

in recent years. When the water table is low, release of hydrostatic pressure on these clays allows the overlying sediments to compress them slightly, thus forcing some of the water out of the minute pore spaces. Subsidence of the land surface, as described in this bulletin, is believed to result from this compression of the clays. Pump repairmen report that in the pressure areas of the northern valley, wrinkles frequently develop in deep well casings at about 200 feet. Another common phenomenon is the rise of casings relative to the ground surface. One driller reported that the top of an old cemented casing at the Palo Alto Yacht Harbor, which was originally at ground level, stood five feet above the surface in 1941.

The source of the underground water is percolation of stream runoff, of rainfall, of unconsumed irrigation water, and percolation pond infiltration in the free ground water areas of the valley. A small amount of water may also be contributed by lateral movement from the Plio-Pleistocene series around the edge of the valley. Once the water reaches the water table, it moves generally toward San Francisco Bay in the northern valley and toward the Pajaro River in the southern valley. In the northern valley no proven outlet of the pressure water is known. The chemical composition of water in a well of low mineral content near Dumbarton Bridge is of such a nature as to indicate that gravels 200 feet deep at that point beneath San Francisco Bay have not been invaded by salt water. There are reports of fresh waters rising in the bay, but their validity has not been proven.

The pressure water of the southern valley joins with the pressure water from San Benito County and probably eventually discharges into the Pajaro River.

GEOLOGIC STRUCTURE

The Santa Clara Valley is, essentially, a down-dropped valley, with uplifted mountains on both sides. The down dropping of the northern basin was accomplished by complex faulting and folding around its margins. The faulting and folding were caused by the same forces, probably acting at the same time. The direction of the forces exerted on the rocks of the California Coast Ranges before middle Pleistocene time is not definitely known. It seems clear, however, that a northward force on the Pacific Ocean side and a southward force on the continental side would produce most of the structures which have formed since that time. (Taliaferro, 1943.)

Folds

Most of the folding of the nonwater-bearing sediments has little relation to the behavior of ground water in the water-bearing sediments. The Plio-Pleistocene water-bearing sediments are generally warped, and are highly folded in small areas near faults.

The most important structural feature in North Santa Clara Valley, as far as ground water is concerned, is the gentle dip of the upper Quaternary and Plio-Pleistocene series from the sides of the valley toward its center. This attitude has been produced by two factors: (1) the original dip of the sediments toward the center of the valley, and (2) the presence of the thickest sediments at the center of the valley, resulting in more settling and compression there than around the edges. In South Santa Clara Valley, the alluvium slopes toward the Pajaro River. It is not known whether the upper Quaternary sediments have been warped additionally by actual sinking of the bedrock beneath the valley relative to the surrounding mountains.

The geologic cross sections (Plate C-4) show the nature of most of the larger folds in the Santa Clara Valley region.

Faults

The largest faults of the Santa Clara Valley region are the San Andreas fault on the west side near the county line, and the Hayward-Calaveras fault system on the east side of the valley. Between these there exists a series of en echelon faults which are most prominent in the southwest part of the county. It seems likely that the latter faults were produced by differential movement along the San Andreas and Hayward-Calaveras faults.

A displacement of approximately one mile has occurred on the San Andreas fault since folding of the Orinda formation in Pliocene time, the southwest side moving, relatively, in a northwesterly direction. (Crittenden, 1951.) The faults shown on Plate C-1 crossing the southern part of the Santa Clara Valley were projected from the outcrops on both sides of the valley.

A small pressure area exists near the western edge of the valley south of Coyote near Bailey Avenue. The confining beds of this pressure area appear to be blue clays of swamp origin. The swamps were probably formed during the deposition of the upper Quaternary sediments when Coyote Creek was temporarily dammed by uplift on the north side of the fault which crosses the valley in the area described above. This same fault has probably produced the prominent scarp-like feature along which Coyote Creek now flows after leaving the upper gorge.

The fault shown on Plate C-1 ending at Evergreen may actually continue through Milpitas to the west side of the Coyote Hills in Alameda County. This fault may form, at least in part, the eastern boundary of the pressure area between Evergreen and Milpitas.

Faulting undoubtedly has some effect on the movement of ground water in the water-bearing series, but ground water levels are apparently too high for any

of these faults to be detected by means of ground water contours.

GEOLOGIC HISTORY AND ORIGIN OF THE PRESENT TOPOGRAPHY

The geologic history of the Santa Clara Valley is generally identifiable with that of the California Coast Ranges. Most of this history has consisted of periodic inundations of the land by the sea, separated by periods of uplift, faulting, folding, and erosion. The complex history prior to the deposition of the Plio-Pleistocene series has little application to this report. Interested readers may obtain some understanding of the salient events by studying the columnar and geologic sections, Plates C-3 and C-4.

The geologic history of the water-bearing series which follows is suggested as being the most reasonable interpretation of the available geologic evidence.

In late Pliocene time, fresh-water streams and lakes were abundant in the San Juan Bautista and Hollister quadrangles and in the northeast part of the Morgan Hill quadrangle. A shoreline of either a bay or the open ocean existed west of Palo Alto. The primitive Diablo Range had formed, as well as the Santa Cruz Range. Both of these were probably lower and not as extensive in area as they are now. In the late Pliocene, the mountains were raised, the streams rejuvenated, and large alluvial fans were formed. At the time of maximum development of the fans, the valley was nearly twice as wide as it is today. Most of the alluvial fans in the northern valley apparently originated on the west side of the valley. It seems likely that some alluvial fans also originated on the east side of the northern valley, since they are known to have been formed on the east side of the southern valley in the Morgan Hill-Gilroy area. It has not been determined whether an arm of San Francisco Bay was present during Plio-Pleistocene time in what is now North Santa Clara Valley.

The topography in lower Pleistocene time was similar to that of today, except that the valley was much wider. The process of erosion and deposition continued until middle Pleistocene time, cutting down the mountains which had formed in the late Pliocene and depositing the sediments in the valley area.

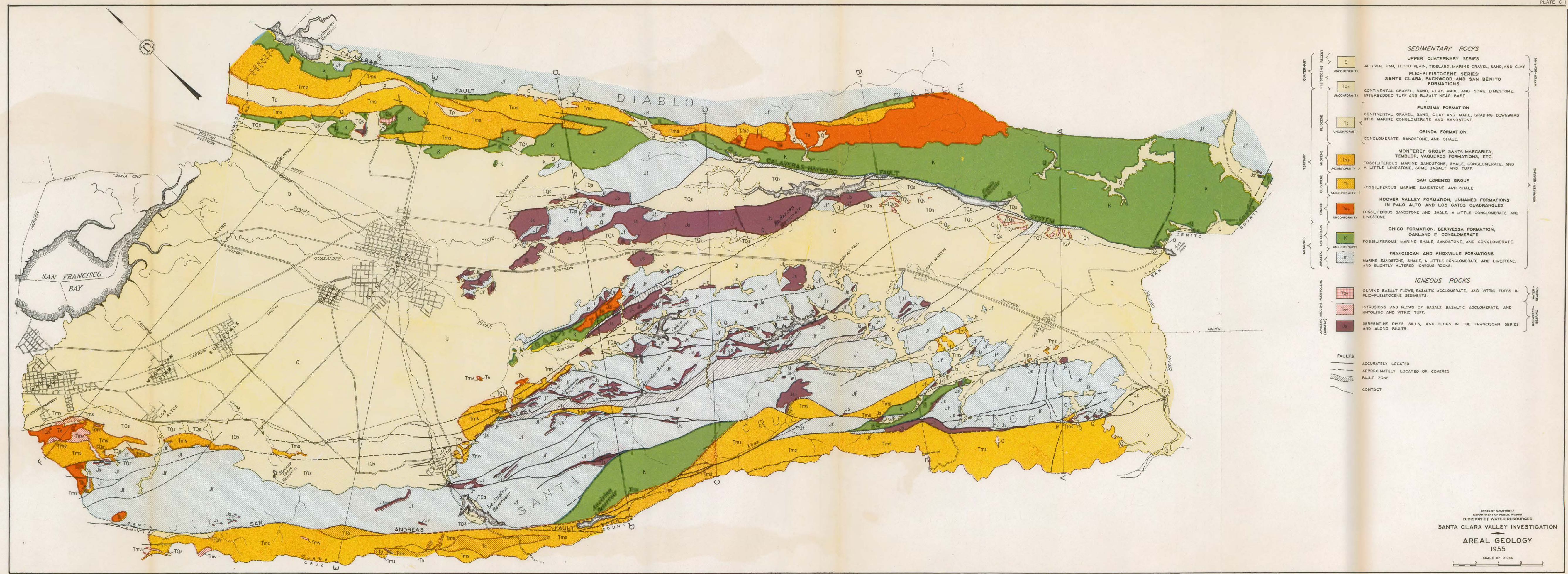
In middle Pleistocene time, the Santa Cruz Mountains and Diablo Range were again uplifted, and the earlier Plio-Pleistocene sediments were faulted, folded near the faults, and eroded around the edge of, but not in, the valley. The older sediments were also folded at this time, and erosion of these continued. This orogeny ended in middle Pleistocene time, but erosion of the deformed mountains continued until a mature erosion surface was formed. This mature surface probably stood at a maximum elevation of 1,000

to 1,500 feet, and it became deeply weathered in most places. The Plio-Pleistocene sediments which were located in the northern valley and which apparently were not uplifted, also underwent weathering, and their clay content was considerably increased by the process. These weathered sediments are now buried by upper Quaternary sediments. It is probable that deposition of upper Quaternary sediments commenced with the beginning of the middle Pleistocene orogeny, which helps to explain the difficulty of differentiating the two series.

The aforementioned erosion surface was subsequently deformed by faulting. During this deformation, which may still be continuing, the erosion surface was broken into blocks. Those blocks which have subsequently risen the highest now form the tops of the ridges. As the blocks rose, accelerated erosion occurred. The sediments from this erosion process

were deposited in the present valley, and constitute the Recent and upper Pleistocene sediments referred to in this appendix. The cutting of deep V-shaped canyons into the old erosion surface and the resultant deposition of sediments is continuing.

The deposition of the upper Quaternary sediments has been in the form of alluvial fan, flood plain, and tideland deposits. The formation of the alluvial fans indicates that the streams wandered back and forth over broad expanses, as is shown today by abandoned gravel stringers which are not connected to active streams. An interesting result of the wandering of the streams on the alluvial fans is that Coyote Creek, after emerging from the upper gorge, has flowed both to the north, as it does today, and to the south. Many of the sediments deposited in the valley south of Morgan Hill have been deposited by Coyote Creek while it flowed to the south.



SEDIMENTARY ROCKS

UPPER QUATERNARY SERIES
ALLUVIAL FAN, FLOOD PLAIN, TIDELAND, MARINE GRAVEL, SAND, AND CLAY

PLIO-PLEISTOCENE SERIES:
SANTA CLARA, PACKWOOD, AND SAN BENITO FORMATIONS
CONTINENTAL GRAVEL, SAND, CLAY, MARL, AND SOME LIMESTONE. INTERBEDDED TUFF AND BASALT NEAR BASE.

PURISIMA FORMATION
CONTINENTAL GRAVEL, SAND, CLAY AND MARL, GRADING DOWNWARD INTO MARINE CONGLOMERATE AND SANDSTONE.

ORINDA FORMATION
CONGLOMERATE, SANDSTONE, AND SHALE.

MONTEREY GROUP, SANTA MARGARITA, TEBLOR, VAQUEROS FORMATIONS, ETC.
FOSSILIFEROUS MARINE SANDSTONE, SHALE, CONGLOMERATE, AND A LITTLE LIMESTONE. SOME BASALT AND TUFF.

SAN LORENZO GROUP
FOSSILIFEROUS MARINE SANDSTONE AND SHALE.

HOOVER VALLEY FORMATION, UNNAMED FORMATIONS IN PALO ALTO AND LOS GATOS QUADRANGLES
FOSSILIFEROUS SANDSTONE AND SHALE. A LITTLE CONGLOMERATE AND LIMESTONE.

CHICO FORMATION, BERRYESSA FORMATION, OAKLAND (?) CONGLOMERATE
FOSSILIFEROUS MARINE SHALE, SANDSTONE, AND CONGLOMERATE.

FRANCISCAN AND KNOXVILLE FORMATIONS
MARINE SANDSTONE, SHALE, A LITTLE CONGLOMERATE AND LIMESTONE, AND SLIGHTLY ALTERED IGNEOUS ROCKS.

IGNEOUS ROCKS

OLIVINE BASALT FLOWS, BASALTIC AGGLOMERATE, AND VITRIC TUFFS IN PLIO-PLEISTOCENE SEDIMENTS.

INTRUSIONS AND FLOWS OF BASALT, BASALTIC AGGLOMERATE, AND RHYOLITIC AND VITRIC TUFF.

SERPENTINE DIKES, SILLS, AND PLUGS IN THE FRANCISCAN SERIES AND ALONG FAULTS.

FAULTS

ACCURATELY LOCATED

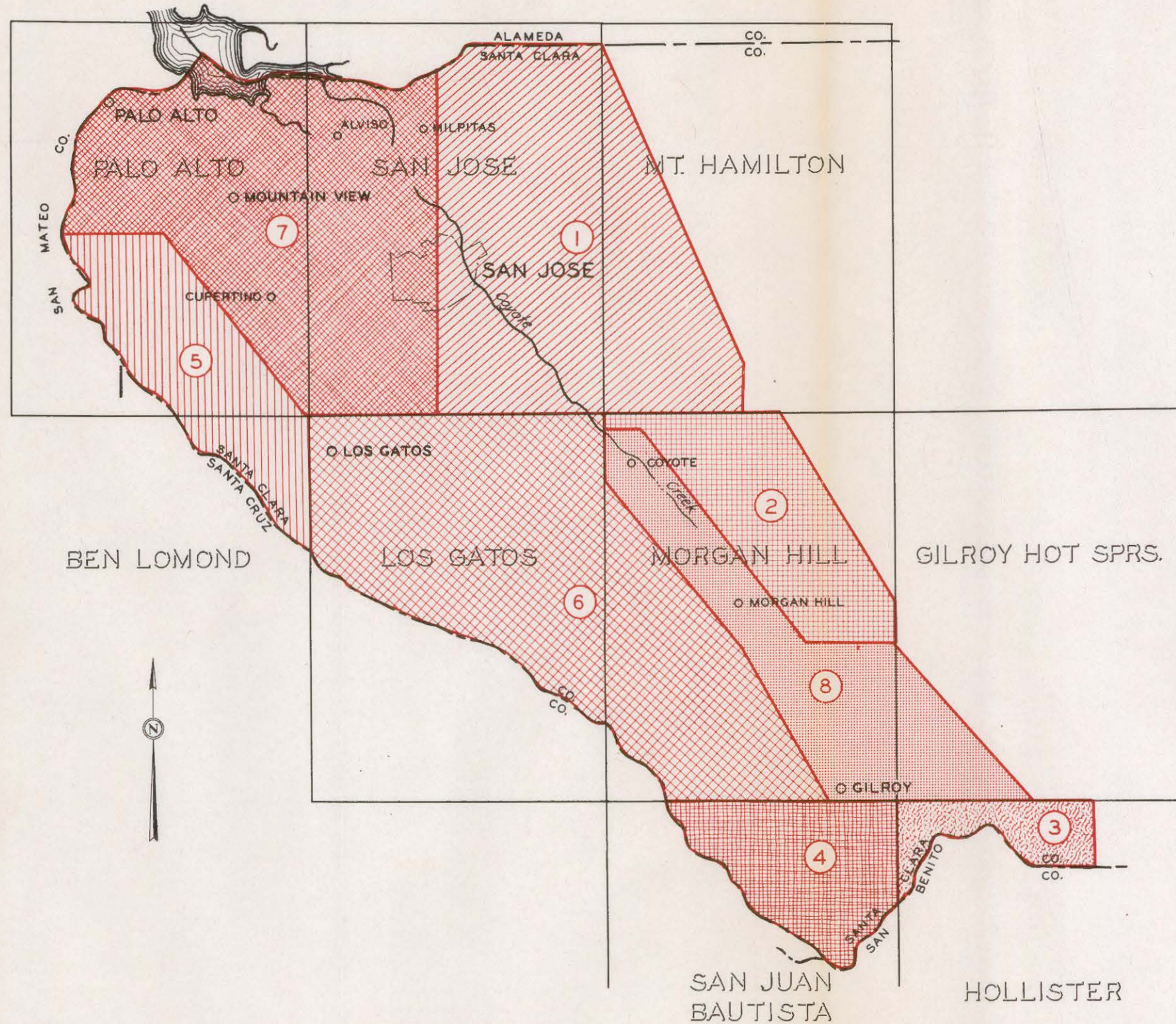
APPROXIMATELY LOCATED OR COVERED

FAULT ZONE

CONTACT

INDEX TO SOURCES OF GEOLOGIC MAP

1. Generalized from *Geology of the San Jose and Mount Hamilton Quadrangles, California*, by Max Crittenden, California Division of Mines Bulletin 157, 1951.
2. Generalized from *Geology of the Northeast Part of the Morgan Hill Quadrangle, California*, by R. A. Ortalda, M. A. Thesis, University of California, 1949.
3. Generalized from *Geology of the Hollister Quadrangle, California*, by N. L. Taliaferro, California Division of Mines Bulletin 143, 1950.
4. Generalized from *Geology of the San Juan Bautista Quadrangle, California*, by J. E. Allen, California Division of Mines Bulletin 133, 1946.
5. Modified from *Geology of the Santa Cruz Quadrangle, California*, by J. C. Branner, J. F. Newsom, and Ralph Arnold, U. S. Geological Survey, Geol. Atlas of the United States, Folio 163, 1909.
6. Modified from original mapping by Edgar H. Bailey, U. S. Geological Survey. This source also used for part of geologic map in *Geologic Guidebook of the San Francisco Bay Counties*, California Division of Mines Bulletin 154, 1951.
7. Generalized from unpublished work by R. G. Thomas, 1948-1949.
8. Mapped during current investigation.

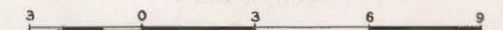


STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
SANTA CLARA VALLEY INVESTIGATION

INDEX MAP

1955

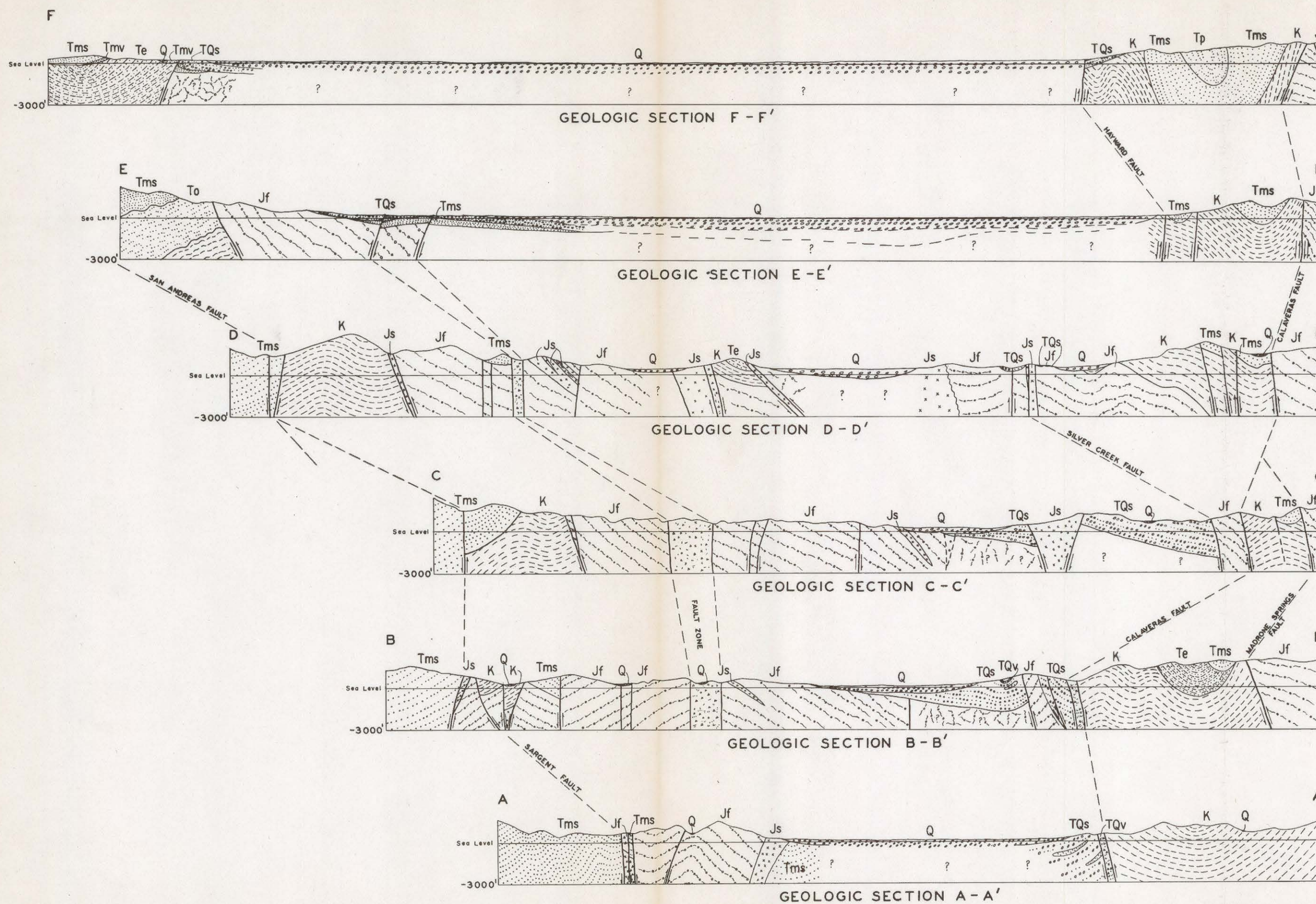
SCALE OF MILES



AGE		PALO ALTO QUADRANGLE	NORTHEAST BEN LOMOND QUADRANGLE	SAN JOSE & MT. HAMILTON QUADRANGLES	LOS GATOS QUADRANGLE	MORGAN HILL QUADRANGLE	NORTH SAN JUAN BAUTISTA QUADRANGLE	NORTH HOLLISTER QUADRANGLE
QUATERNARY	RECENT	ALLUVIAL AND TIDELAND DEPOSITS 0-800' GRAVEL, SAND, SILT, AND CLAY.	NOT PRESENT	ALLUVIAL AND TIDELAND DEPOSITS 0-1000' GRAVEL, SAND, SILT, AND CLAY.	ALLUVIUM 0-300' GRAVEL, SAND, SILT, AND CLAY.	ALLUVIUM 0-400' SAND, GRAVEL, SILT, AND CLAY.	ALLUVIUM 0-200' CLAY, SILT, AND GRAVEL.	ALLUVIUM 0-400' CLAY, SILT, AND GRAVEL.
	PLEISTOCENE	SANTA CLARA FM. 400' [±] GRAVEL, SAND, AND CLAY. FOSSILIFEROUS MARINE SAND AT BASE.	SANTA CLARA FM. 500' [±] GRAVEL, SAND, AND CLAY.	SANTA CLARA FM. GRAVEL AND CLAY. PACKWOOD GRAVELS GRAVEL AND SAND	SANTA CLARA FM. GRAVEL, SAND, AND CLAY, SOME MARL AND FRESHWATER LIMESTONE.	PACKWOOD GRAVELS 4500' [±] POORLY SORTED, CROSS-BEDDED CONGLOMERATE, SANDSTONE, MUDSTONE, AND THEIR UNCONSOLIDATED EQUIVALENTS. SOME MARL, TUFF, OLIVINE BASALT, AND BASALT AGGLOMERATE INTERBEDDED NEAR BASE.	TERRACES 0-50' GRAVEL	SAN BENITO GRAVELS 1000' GRAVEL, SAND, SILT, CLAY, AND SOME OLIVINE BASALT.
TERTIARY	PLIOCENE						PURISIMA FM 7000-10000' CROSS-BEDDED, GYPSEIFEROUS, CONTINENTAL GRAVEL, GRIT, AND SAND GRADING DOWNWARD INTO FOSSILIFEROUS MARINE GRAVEL, SAND, SILT, AND BASAL CONGLOMERATE.	
			SANTA MARGARITA FM. 300' [±] SANDSTONE, CONGLOMERATE, AND SHALE.	ORINDA FM. 750-2000' RED CONGLOMERATE, SANDSTONE, AND SHALE. BRIONES SANDSTONE 3450-5000' MASSIVE FOSSILIFEROUS SANDSTONE.		NOT IN CONTACT BRIONES FM. 500' MASSIVE FOSSILIFEROUS SANDSTONE.		
	MIOCENE	MONTEREY SHALE 400' [±] SILICEOUS AND CLAY SHALE. TEMBLOR FM. 2000' FOSSILIFEROUS MARINE SANDSTONE, BASALT FLOWS AND AGGLOMERATE NEAR BASE.	MONTEREY SHALE 5000' [±] SILICEOUS AND CLAY SHALE; SANDSTONE.	MONTEREY FM. 500' SANDSTONE, SHALE, AND CHERT.	MONTEREY FM. 1600' SHALE WITH SOME SANDSTONE.	MONTEREY FM. 1400' SILICEOUS, SHALE, CHERT, AND SANDSTONE. LIMESTONE LENSES AND ASH BEDS NEAR TOP.	MONTEREY GROUP 2000-3000' DIATOMACEOUS, SILICEOUS, AND CLAY SHALE, LIMESTONE LENSES, ARKOSIC SANDSTONE, AND GRIT.	
			VAQUEROS SANDSTONE 2700' [±] MASSIVE SANDSTONE.	TEMBLOR FM. 750' FOSSILIFEROUS SANDSTONE.	TEMBLOR FM. 1400' FOSSILIFEROUS SANDSTONE.			
	OLIGOCENE		SAN LORENZO GROUP 2500' [±] MASSIVE SANDSTONE AND SHALE.					
CRETACEOUS	EOCENE	UNNAMED-CHICO OF BRANNER 3000' [±] MASSIVE SANDSTONE AND FORAMINIFERAL SHALE.			UNNAMED 500' [±] SANDSTONE, SHALE, AND FOSSILIFEROUS LIMESTONE.	HOOVER VALLEY FM. 3750' SHALE, ARKOSIC SANDSTONE, RARE CONGLOMERATE LENSES WITH A DISCONTINUOUS PEBBLY SANDSTONE AT BASE.		UPPER 3000' SANDSTONE, SHALE, AND CONGLOMERATE.
				BERRYESSA FM. 1600-2000' SILTSTONE AND SANDSTONE.	CHICO FM. 1000' [±] SANDSTONE AND SHALE. FAULT CONTACT UNNAMED 5000' [±] SANDSTONE, SOME SHALE AND CONGLOMERATE.	BERRYESSA FM. 3700' MICACEOUS, ARKOSIC SANDSTONE, DARK CLAY SHALE, AND LARGE CONGLOMERATE LENSES.		LOWER 7000' DARK SHALE AND THIN SANDSTONE.
UPPER JURASSIC				OAKLAND (?) CONGLOMERATE 3000-7000' MASSIVE CONGLOMERATE AND SOME SANDSTONE AND SHALE.				
		FRANCISCAN GROUP 3000' [±] SANDSTONE, SHALE, CHERT, LIMESTONE, ALTERED IGNEOUS ROCKS, AND SERPENTINE.	FRANCISCAN GROUP 3000' [±] SANDSTONE, SHALE, CHERT, LIMESTONE, ALTERED IGNEOUS ROCKS, AND SERPENTINE.	KNOXVILLE GROUP DARK SHALE AND THIN SANDSTONE.	FRANCISCAN GROUP 12000' [±] SANDSTONE, SHALE, CHERT, LIMESTONE, ALTERED IGNEOUS ROCKS, AND SERPENTINE.	KNOXVILLE GROUP DARK GRAY SHALE WITH INTERBEDDED ARKOSIC SANDSTONE.	FRANCISCAN GROUP 8000-10000' SANDSTONE, SHALE, SOME CONGLOMERATE, BASALT, CHERT, LIMESTONE, AND SERPENTINE.	FRANCISCAN GROUP 5000' [±] CHIEFLY ARKOSIC SANDSTONE. SOME CHERT AND BASALT.

COLUMNAR SECTIONS INCLUDE ONLY THE AREA SHOWN ON GEOLOGIC MAP.

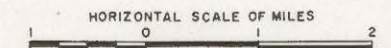
COLUMNAR SECTIONS - SANTA CLARA COUNTY



- LEGEND**
- SEDIMENTARY ROCKS**
- Q ALLUVIAL AND TIDELAND DEPOSITS
 - TQs SANTA CLARA, PACKWOOD, AND SAN BENITO FORMATIONS
 - Tp PURISIMA AND ORINDA FORMATIONS
 - TMs MONTEREY GROUP, SANTA MARGARITA TEBLOR, VAQUEROS FORMATIONS, ETC.
 - To SAN LORENZO GROUP
 - Te HOOVER VALLEY FORMATION, UNNAMED FORMATIONS IN PALO ALTO AND LOS GATOS QUADRANGLES
 - K CHICO FORMATION, BERRYESSA FORMATION, OAKLAND (?) CONGLOMERATE
 - Jf FRANCISCAN AND KNOXVILLE FORMATIONS
- IGNEOUS ROCKS**
- TQv PLIO-PLISTOCENE BASALT AND TUFF
 - TMv MIOCENE BASALT AND TUFF
 - Js SERPENTINE

NOTE: LINES OF SECTIONS APPEAR ON PLATE C-1

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
SANTA CLARA VALLEY INVESTIGATION
GEOLOGIC SECTIONS
1955



APPENDIX D

RECORDS OF MONTHLY PRECIPITATION IN SANTA CLARA
VALLEY NOT PREVIOUSLY PUBLISHED

(On file with the Division of Water Resources)

APPENDIX E

**RECORDS OF DAILY RUNOFF IN SANTA CLARA VALLEY
NOT PREVIOUSLY PUBLISHED**

(On file with the Division of Water Resources)

APPENDIX F

**RECORDS OF DEPTHS TO GROUND WATER AT SELECTED
WELLS IN SANTA CLARA VALLEY**

(On file with the Division of Water Resources)

APPENDIX G

RECORDS OF PARTIAL MINERAL ANALYSES OF GROUND
WATERS IN SANTA CLARA VALLEY

PARTIAL MINERAL ANALYSES OF GROUND WATERS IN SANTA CLARA VALLEY

Well number		Depth, in feet	Use	Date of sample	Chlo- rides, in epm	Solids, in ppm	Well number		Depth, in feet	Use	Date of sample	Chlo- rides, in epm	Solids, in ppm
Division of Water Resources	Poland*						Division of Water Resources	Poland*					
5S/1W-36H1	B14	368	Domestic	11/16/38	0.79		6S/1W-12R1			Irrigation	5/11/49	1.13	450
5S/3W-35G1		303		5/18/49	1.13	425	6S/1W-13F1			Irrigation and domestic	8/24/49	0.85	370
				7/18/49	3.94	540				Irrigation	5/11/49	1.13	460
				8/18/49	3.10	530				Irrigation	8/15/49	0.85	370
5S/1E-31E1		200	Domestic	5/12/49	0.56	380	6S/1W-13J1			Irrigation	5/11/49	0.56	405
				8/25/49	0.56	340				Irrigation	8/24/49	0.85	360
5S/1E-32P1		250	Irrigation	5/10/49	3.38	900	6S/1W-14C1	B57		Irrigation	11/23/38	0.79	
				8/17/49	2.82	670					7/13/49	1.13	330
6S/1W-1J1			Irrigation	5/10/49	0.85	460					9/ 8/49	0.56	260
				8/16/49	0.56	290	6S/1W-14E2	B123	469	Irrigation	4/27/39	1.18	
6S/1W-1L1	B29		Irrigation	11/18/38	0.70		6S/1W-14E3			Irrigation and domestic	5/11/49	0.56	350
				5/11/49	0.85	405							
				9/19/49	0.85	350	6S/1W-14L4				5/11/49	3.10	960
6S/1W-1M1	B42	300	Irrigation	11/21/38	0.99		6S/1W-14M1	B119	135	Irrigation and domestic	8/16/49	3.10	600
6S/1W-1P1	B22			11/18/38	0.79						4/27/39	0.48	
				5/11/49	1.13	445							
				9/19/49	0.85	350	6S/1W-14R1		516		5/16/49	0.85	340
6S/1W-1P2	B24		Irrigation	11/18/38	0.79						9/ 8/49	0.56	250
				5/11/49	1.13	445	6S/1W-15C2	B60		Irrigation and domestic	11/23/38	5.58	
				8/14/49	0.85	330					5/11/49	11.53	1600
6S/1W-1Q1	B21	250- 275	Irrigation	11/18/38	0.99						7/13/49	11.25	1750
				5/10/49	1.13	445	6S/1W-15F1	B92			8/24/49	12.68	1400
				8/30/49	0.85	260					11/28/38	0.51	
6S/1W-1R1			Irrigation	8/16/49	1.13	460					5/12/49	0.85	310
				9/19/49	1.13	400	6S/1W-15F2	B93	100	Irrigation	8/15/49	0.56	260
6S/1W-2R1	B45	257	Irrigation	11/21/38	0.93						11/28/38	18.00	
				5/16/49	1.13	370					5/10/49	11.27	
				8/15/49	0.56	330	6S/1W-15L1	B112	323	Domestic	8/15/49	13.24	
6S/1W-3R1	B47			11/21/38	1.41		6S/1W-16A1		551		4/26/39	0.39	
				5/10/49	0.56	370					5/12/49	0.28	290
				8/15/49	1.13	330	6S/1W-16F1	B100	435		8/24/49	0.28	240
6S/1W-10E1	B74		Irrigation	11/26/38	0.99						12/ 1/38	2.08	
				5/12/49	0.56	310	6S/1W-16J1		675	Irrigation	8/15/49	0.56	270
6S/1W-10E2	B70	385	Irrigation	11/26/38	1.89						5/16/49	0.28	310
6S/1W-10K1	B50		Irrigation	11/23/38	0.70		6S/1W-17G1		492	Domestic	8/24/49	0.28	270
				9/19/49	0.85	370					5/12/49	2.54	860
6S/1W-10N1			Irrigation	5/12/49	1.13	380	6S/1W-17K1	B5	583		8/15/49	2.25	700
				7/13/49	1.13	350					11/15/39	1.80	
				8/15/49	1.41	330					5/19/49	1.69	870
6S/1W-10P1			Domestic	5/12/49	0.85	340					7/12/49	1.97	710
				8/15/49	0.56	290	6S/1W-17M1		600	Irrigation	8/15/49	1.69	700
6S/1W-10P2	B66	368	Irrigation and domestic	/38	0.90		6S/1W-18K1	C11	230	Irrigation and domestic	5/17/49	0.59	300
											12/ 6/38	0.46	
6S/1W-10P3			Irrigation	5/16/49	3.10	800	6S/1W-18L1	C8	150	Irrigation	12/ 5/38	2.59	
				8/15/49	3.66	660					5/16/49	2.82	1100
6S/1W-11A1	B30		Irrigation	11/18/38	0.79						7/22/49	3.38	1000
6S/1W-11B1	B19	360	Irrigation	11/16/38	0.99		6S/1W-18N1				8/ 3/49	0.31	930
6S/1W-11C1				5/11/49	0.85	440					5/18/49	0.11	340
6S/1W-11J1	B35		Irrigation	11/21/38	0.90		6S/1W-18P1	C21	305	Irrigation	8/26/49	0.84	295
6S/1W-11K1	B37	575	Irrigation	11/21/38	1.18		6S/1W/18Q1		37	Irrigation and domestic	12/ 7/38	0.90	
				5/16/49	0.56	360					5/16/49	1.13	470
				8/30/49	0.56	310					8/ 3/49	1.13	430
6S/1W-11L1	B41		Irrigation	11/21/38	0.79		6S/1W-18R2	C5		Irrigation	9/ 6/49	1.13	390
6S/1W-11M1			Irrigation	5/11/49	0.85	340	6S/1W-19F1			Irrigation	12/ 5/38	0.59	
				7/13/49	0.56	350					5/17/49	1.41	630
6S/1W-11N1	B53	608	Irrigation	11/23/38	2.39		6S/1W-19M1		495	Irrigation and domestic	8/ 3/49	1.41	460
6S/1W-11P1	B54		Irrigation and domestic	11/23/38	0.99						5/16/49	1.13	520
				5/12/49	0.85	350					7/13/49	1.13	390
				7/13/49	0.85	315	6S/1W-20A1		495	Irrigation and domestic	8/16/49	0.85	370
				8/16/49	0.85	320					5/12/49	0.56	290
6S/1W-11R1	B34		Domestic	11/21/38	0.99						7/17/49	0.56	255
				5/11/49	0.56	390	6S/1W-20D1				9/ 8/49	0.28	240
				8/15/49	0.56	330	6S/1W-21H1		469	Irrigation	10/ 3/49	0.56	290
6S/1W-12A1			Irrigation	5/10/49	0.85	490	6S/1W-21R1			Irrigation	9/23/49	0.56	300
				8/16/49	0.85	330					5/12/49	0.28	300
6S/1W-12C1	B25		Domestic	11/18/38	0.79		6S/1W-22J1		815	Domestic	5/12/49	1.13	350
				5/11/49	0.85	290					8/16/49	0.56	270
6S/1W-12D2			Irrigation	5/16/49	1.13	410	6S/1W-23H1		515	Irrigation	5/11/49	0.56	370
				8/15/49	0.56	370					8/16/49	0.56	310
6S/1W-12E1	B31		Irrigation and domestic	11/18/38	0.90		6S/1W-24F1				5/11/49	2.25	690
											8/24/49	1.97	660
6S/1W-12K1	C5		Irrigation	12/ 5/38	0.59		6S/1W-25D1		360	Irrigation	5/11/49	1.69	830
				5/19/49	0.85	390					7/13/49	1.69	650
6S/1W-12M2		323		9/19/49	0.56	340					9/27/49	2.25	620
				5/11/49	0.85	390							
6S/1W-12N1		300	Irrigation	8/24/49	0.56	330							

SANTA CLARA VALLEY INVESTIGATION

PARTIAL MINERAL ANALYSES OF GROUND WATERS IN SANTA CLARA VALLEY—Continued

Well number		Depth, in feet	Use	Date of sample	Chlo- rides, in epm	Solids, in ppm	Well number		Depth, in feet	Use	Date of sample	Chlo- rides, in epm	Solids, in ppm
Division of Water Resources	Poland*						Division of Water Resources	Poland*					
6S/1W-25L2-----		390	Irrigation-----	5/11/49	0.56	340	6S/2W-10F1-----		187	Domestic-----	5/19/49	1.13	325
				7/13/49	0.56	350					8/22/49	0.56	310
6S/1W-26D1-----		649		9/ 7/49	0.56	250	6S/2W-10N1-----	C69		Irrigation-----	12/29/38	0.70	
				5/16/49	0.85	290	6S/2W-10N2-----	C68	300	Irrigation-----	12/29/38	0.79	
6S/1W-26F2-----			Irrigation-----	9/ 7/49	0.56	330	6S/2W-12P1-----	C32	175	Stock-----	12/ 8/38	2.20	
				5/16/49	0.56	360					5/19/49	3.10	870
6S/1W-27F1-----			Irrigation and domestic-----	9/19/49	0.56	320					8/22/49	3.66	780
				5/16/49	0.56	310	6S/2W-13J1-----	C36		Domestic-----	12/ 8/38	2.08	
				7/13/49	0.56	265					5/19/49	1.41	610
6S/1W-27Q1-----			Irrigation and domestic-----	9/ 8/49	0.28	270					8/22/49	1.41	470
				5/12/49	0.56	270	6S/2W-13M1-----	C28		Irrigation-----	12/ 8/38	0.90	
				7/13/49	0.56	265					5/19/49	0.85	425
6S/1W-27R1-----		360	Irrigation-----	9/23/49	0.28	230					8/22/49	1.69	580
				5/12/49	0.85	370	6S/2W-13N1-----	C29		Irrigation and domestic-----	12/ 8/38	1.18	
				7/13/49	0.56	350							
6S/1W-29C1-----		375	Irrigation-----	8/16/49	0.28	310	6S/2W-14M1-----	C41	1000	Municipal-----	12/23/38	8.48	
				5/12/49	0.56	315					5/18/49	1.69	400
6S/1W-29G1-----		250		8/23/49	0.56	290					7/18/49	0.28	460
				5/12/49	0.56	340					8/22/49	0.28	90
				8/ 3/49	0.56	315	6S/2W-14M2-----	C40	800	Municipal-----	12/23/38	18.20	
6S/1W-29M2-----		540		8/23/49	0.28	270					5/18/49	6.20	770
				5/17/49	1.13	445					7/18/49	7.04	750
				8/ 3/49	1.13	430					8/22/49	5.92	700
6S/1W-29P1-----			Irrigation-----	9/ 6/49	0.85	390	6S/2W-14R1-----		700		5/19/49	1.69	370
				5/17/49	0.56	315					7/18/49	1.41	365
6S/1W-30C4-----			Irrigation and domestic-----	9/16/49	0.56	260					9/12/49	1.41	360
				5/16/49	1.13	470	6S/2W-15D1-----		700	Irrigation-----	5/19/49	0.56	355
				8/ 3/49	1.13	430					7/14/49	0.85	280
6S/1W-30P1-----			Irrigation-----	9/ 6/49	1.13	390					8/22/49	0.56	340
				5/17/49	1.41	485	6S/2W-15E1-----	C52		Irrigation-----	12/28/38	0.70	
				8/23/49	1.41	430					5/19/49	1.13	390
6S/1W-31L3-----		381	Irrigation-----	9/ 6/49	1.14	370					8/22/49	0.85	430
				5/16/49	0.56	360	6S/2W-15F1-----	C49		Irrigation-----	12/28/38	0.59	
6S/1W-31P1-----			Irrigation-----	8/23/49	0.85	330	6S/2W-16H1-----		600	Irrigation-----	5/19/49	0.85	315
6S/1W-32Q1-----		350	Irrigation and domestic-----	5/12/49	0.85	315					7/14/49	1.13	460
				5/17/49	0.56	315					9/19/49	0.56	290
6S/1W-33C1-----				9/ 6/49	0.56	280	6S/2W-16Q1-----			Irrigation-----	5/19/49	1.13	470
				5/11/49	0.85	390					9/19/49	0.85	400
6S/1W-33L1-----		391	Irrigation and domestic-----	8/15/49	0.56	330	6S/2W-18B4-----		350	Irrigation-----	5/18/49	0.85	325
				5/17/49	0.56	325	6S/2W-18N2-----		705	Irrigation-----	5/18/49	1.13	400
6S/1W-34L1-----		420	Irrigation-----	9/20/49	0.56	280					8/18/49	1.13	390
				5/16/49	0.56	450	6S/2W-20C1-----		340	Irrigation-----	5/19/49	1.41	460
				9/ 7/49	0.56	300					9/19/49	1.41	430
6S/1W-34L2-----				7/13/49	0.85	350	6S/2W-20G2-----		310	Irrigation and domestic-----	5/19/49	2.25	500
6S/1W-34P1-----			Irrigation-----	5/17/49	0.85	370					9/19/49	1.13	340
				7/14/49	0.56	315	6S/2W-22C1-----			Irrigation-----	5/19/49	0.56	370
				9/22/49	0.85	370					9/19/49	0.85	350
6S/1W-34R1-----			Irrigation and domestic-----	5/12/49	1.13	560	6S/2W-22H7-----		150	Irrigation and domestic-----	5/19/49	0.85	460
				7/13/49	0.85	480					8/22/49	1.41	400
6S/1W-35N1-----		722	Industrial-----	9/ 8/49	0.85	470	6S/2W-22K1-----			Irrigation-----	5/19/49	1.13	390
				5/16/49	1.13	390					9/19/49	0.56	340
6S/1W-36E1-----			Abandoned-----	9/19/49	0.56	330	6S/2W-22Q1-----			Irrigation-----	5/20/49	1.13	355
				5/16/49	0.85	380					8/22/49	0.56	340
6S/1W-36F1-----		350		8/24/49	2.55	1060	6S/2W-23D1-----			Irrigation and stock-----	5/19/49	1.41	340
				5/11/49	0.56	390					7/18/49	1.13	460
6S/1W-36G1-----		350	Irrigation-----	9/ 7/49	0.56	390					8/22/49	1.13	340
				5/11/49	0.85	480	6S/2W-23M1-----			Irrigation-----	5/19/49	0.85	460
6S/1W-36J1-----		430	Irrigation-----	7/13/49	0.85	390	6S/2W-24A1-----		677	Irrigation-----	5/16/49	0.85	300
				5/15/49	0.56	380	6S/2W-24C1-----				5/19/49	0.85	590
				10/ 4/49	0.5	310					7/18/49	0.56	365
6S/2W-6D2-----	D99	352	Abandoned-----	4/20/39	0.70						8/22/49	0.85	360
6S/2W-7D1-----	D21	225	Municipal-----	4/11/39	0.99		6S/2W-24C2-----		800	Irrigation-----	5/16/49	1.13	520
6S/2W-7J1-----			Irrigation and domestic-----	5/19/49	4.23	1100					7/18/49	0.85	330
				7/18/49	4.23	870					8/22/49	0.56	320
				8/18/49	4.78	900	6S/2W-24D1-----		665	Irrigation-----	5/19/49	0.85	335
6S/2W-8J1-----		125		5/18/49	1.13	305					7/18/49	1.13	365
				7/18/49	0.85	315					9/12/49	0.85	340
				8/22/49	0.56	320	6S/2W-24M2-----		550		5/16/49	1.13	340
				4/18/39	1.16						9/ 6/49	0.85	290
6S/2W-8N1-----	D57	505	Irrigation and domestic-----				6S/2W-24P3-----			Irrigation and domestic-----	5/19/49	0.85	340
			Irrigation-----	5/18/49	0.85	365					9/20/49	0.85	330
6S/2W-8N4-----				8/22/49	1.41	580	6S/2W-26H2-----		400	Irrigation and domestic-----	5/19/49	0.85	355
6S/2W-8N5-----	D66	400	Dairy-----	4/18/39	0.90						9/ 9/49	0.56	245
6S/2W-9H1-----		200		5/19/49	1.13	365	6S/2W-26N2-----		185	Irrigation-----	5/17/49	0.28	380
				8/22/49	0.85	290					9/20/49	0.56	310
6S/2W-9L1-----	D36			4/12/39	0.99		6S/2W-27F1-----		387	Irrigation-----	5/19/49	0.85	325
				5/19/49	1.69	870					8/22/49	0.85	390
				8/22/49	1.97	780							

PARTIAL MINERAL ANALYSES OF GROUND WATERS IN SANTA CLARA VALLEY—Continued

Well number		Depth, in feet	Use	Date of sample	Chlo- rides, in epm	Solids, in ppm	Well number		Depth, in feet	Use	Date of sample	Chlo- rides, in epm	Solids, in ppm
Division of Water Resources	Poland*						Division of Water Resources	Poland*					
6S/2W-27H2			Irrigation	5/19/49	0.85	370	6S/1E-16R1			Irrigation	10/ 3/49	2.54	700
6S/2W-27Q1		287	Irrigation and domestic	9/20/49	0.56	330	6S/1E-17H1		463	Irrigation	5/11/49	0.85	415
6S/2W-27Q2		375	Irrigation	5/19/49	0.85	460	6S/1E-17R1		300	Irrigation	5/10/49	1.41	580
6S/2W-28M1		600	Municipal	5/20/49	1.13	325	6S/1E-18D1		354	Irrigation	8/17/49	1.41	460
6S/2W-29A1		500	Irrigation	9/19/49	0.56	320	6S/1E-18L1		120	Irrigation and domestic	5/11/49	0.85	460
6S/2W-29D2		500	Irrigation	5/20/49	1.13	380	6S/1E-19F1		120	Irrigation and domestic	8/15/49	0.85	300
6S/2W-32C1		500	Irrigation	7/14/49	0.85	365	6S/1E-19M1		120	Irrigation and domestic	5/11/49	1.13	490
6S/2W-33A1		500	Irrigation	8/22/49	1.13	380	6S/1E-19Q1		120	Irrigation and domestic	8/15/49	0.85	390
6S/2W-34M1		660	Irrigation	5/20/49	0.85	390	6S/1E-21G1		120	Irrigation and domestic	5/11/49	2.28	570
6S/2W-35B3		225	Irrigation and domestic	8/31/49	0.85	370	6S/1E-21Q1		120	Irrigation and domestic	9/ 7/49	0.85	370
6S/2W-35M1		500	Irrigation	10/ 3/49	0.85	370	6S/1E-22B2		120	Irrigation and domestic	8/16/49	0.85	370
6S/2W-36H2		470	Irrigation	5/20/49	0.85	355	6S/1E-22E2		120	Irrigation	5/16/49	0.85	420
6S/2W-36L1		700	Irrigation	9/12/49	0.85	380	6S/1E-26G1		120	Irrigation	9/ 7/49	0.56	370
6S/2W-36M1		700	Irrigation	5/17/49	0.56	315	6S/1E-27H1		396	Irrigation	5/10/49	1.69	485
6S/3W-1B1		750	Municipal	8/23/49	0.56	260	6S/1E-27P2		396	Irrigation	5/17/49	1.13	470
6S/3W-1D1		750	Municipal	5/19/49	0.86	425	6S/1E-29B2		460	Irrigation	9/19/49	0.85	380
6S/3W-1M1		400	Municipal	10/ 3/49	0.56	370	6S/1E-30M1		460	Irrigation	5/16/49	2.54	800
6S/3W-2D1		367	Municipal	8/ 3/49	0.56	315	6S/1E-30N1		316	Irrigation	10/ 4/49	2.54	760
6S/3W-3L1		746	Municipal	8/23/49	0.56	300	6S/1E-31L3		316	Irrigation	5/15/49	1.69	560
6S/3W-3P1		320	Municipal	5/16/49	1.41	470	6S/1E-33H1		341	Irrigation	8/25/49	1.13	460
6S/3W-12C1		525	Municipal	9/23/49	1.41	390	6S/1E-33L1		341	Irrigation	5/17/49	1.97	690
6S/3W-12G1		512	Municipal	5/18/49	2.82	460	6S/1E-34H2		303	Irrigation	8/25/49	1.41	490
6S/1E-1P2	B24			7/18/49	1.97	500	6S/1E-34Q1		430	Irrigation	5/15/49	0.56	380
6S/1E-1Q1	B21	275		8/18/49	1.97	430	7S/1W-3G1		550	Irrigation	10/ 4/49	0.56	310
6S/1E-4L1		200	Irrigation	5/18/49	1.41	425	7S/1W-4B1		360	Irrigation	5/17/49	0.85	380
6S/1E-5G1		278	Irrigation	7/18/49	1.13	390	7S/1W-4D1		300	Irrigation	7/14/49	0.56	314
6S/1E-5Q1			Domestic	8/18/49	1.13	430	7S/1W-5E1		229	Irrigation and domestic	9/20/49	0.56	330
6S/1E-6A1			Irrigation and domestic	5/18/49	1.41	425	7S/1W-5F1		440	Irrigation	5/17/49	0.28	295
6S/1E-7E1	B26		Municipal	7/18/49	1.13	390	7S/1W-5N2			Irrigation	8/26/49	0.56	240
6S/1E-8N1		506	Municipal	8/18/49	4.78	670	7S/1W-5Q2			Irrigation	5/17/49	0.56	315
6S/1E-8Q1		614	Irrigation	7/18/49	4.78	600	7S/1W-6C1		465	Irrigation	9/12/49	0.56	280
6S/1E-9B1		315	Domestic	8/18/49	4.23	640	7S/1W-6P1		606	Irrigation	5/17/49	1.41	560
6S/1E-15L1		452		11/18/38	0.79		7S/1W-6Q1			Irrigation	5/15/49	0.85	340
6S/1E-16F1		493	Irrigation	5/11/49	1.13	445	7S/1W-7F1		585	Irrigation	8/31/49	0.56	290
6S/1E-16G1		500	Irrigation	8/16/49	0.85	260	7S/1W-7H1		310	Irrigation	9/12/49	0.56	290
6S/1E-16P1		400	Irrigation	5/10/49	1.97	760	7S/1W-8H1		360	Irrigation	5/17/49	0.85	410
				8/30/49	2.25	620							
				5/10/49	2.82	730							
				8/17/49	2.54	620							
				5/10/49	1.41	600							
				8/30/49	1.14	500							
				5/10/49	0.85	405							
				8/13/49	0.57	330							
				11/18/38	1.80								
				5/10/49	1.69	630							
				8/25/49	1.97	550							
				5/10/49	1.13	405							
				7/13/49	0.85	350							
				8/17/49	0.85	340							
				5/10/49	2.54	730							
				8/30/49	2.25	500							
				5/10/49	3.66	950							
				8/17/49	3.10	780							
				5/16/49	1.69	560							
				9/ 7/49	1.41	460							
				5/10/49	1.41	580							
				8/30/49	1.42	500							
				5/10/49	1.69	600							
				9/ 7/49	1.97	500							

PARTIAL MINERAL ANALYSES OF GROUND WATERS IN SANTA CLARA VALLEY—Continued

Well number		Depth, in feet	Use	Date of sample	Chlo- rides, in epm	Solids, in ppm	Well number		Depth, in feet	Use	Date of sample	Chlo- rides, in epm	Solids, in ppm	
Division of Water Resources	Poland*						Division of Water Resources	Poland*						
7S/1W-9M1		281	Irrigation	5/17/49	0.56	300	7S/1E-9D1		325	Dairy	10/ 4/49	0.56	400	
				9/20/49	0.28	270	7S/1E-10B1			Irrigation and domestic	5/15/49	0.85	560	
7S/1W-11N1		634	Irrigation	5/19/49	1.13	570			187		5/12/49	1.13	520	
7S/1W-13K1	Municipal		10/ 4/49	0.56	300	7S/1E-14C2				7/12/49	0.56	430		
7S/1W-14G1			10/ 3/49	0.85	370			8/24/49		0.85	400			
7S/1W-14M1	Irrigation		9/ 7/49	0.56	300			5/12/49		1.67	630			
7S/1W-16A1	Irrigation		5/18/49	0.85	325	7S/1E-14R2				9/ 6/49	1.40	490		
				9/23/49	0.56	280				Irrigation and domestic	5/12/49	0.85	580	
7S/1W-16D1		312		5/13/49	0.85	315	7S/1E-15J2							
				9/20/49	0.56	270								
7S/1W-16H1		313		5/20/49	0.85	325	7S/1E-20Q6			300	Municipal	10/ 4/49	0.56	300
				7/12/49	0.56	285	7S/1E-21K2				10/ 4/49	0.56	400	
				8/26/49	0.56	310	7S/1E-22P1				10/ 4/49	0.85	380	
7S/1W-17F1			Irrigation	5/18/49	0.28	305					5/11/49	0.56	470	
7S/1W-18G1		420	Irrigation	5/18/49	0.85	340	7S/1E-23K1				8/25/49	0.56	380	
				8/31/49	0.85	320					5/12/49	0.85	450	
7S/1W-18N1		525	Irrigation	5/18/49	1.13	340	7S/1E-24R1				7/12/49	3.95	710	
				8/26/49	0.85	290					8/24/49	4.23	760	
7S/1W-19E1		400	Irrigation	5/18/49	1.13	340					5/11/49	0.85	460	
				9/20/49	0.85	310	7S/1E-25E4		268	Irrigation	7/12/49	1.13	390	
7S/1W-19K1		560	Irrigation and domestic	5/19/49	0.56	290					8/25/49	0.85	400	
											10/ 4/49	0.85	400	
7S/1W-20B1		285	Irrigation	5/18/49	0.85	325	7S/1E-26E2		164	Irrigation and domestic				
				9/ 7/49	0.56	340					5/11/49	1.67	630	
7S/1W-20K2		450	Irrigation	5/19/49	0.85	320	7S/1E-27A2				5/15/49	0.56	350	
				9/ 7/49	0.56	300	7S/1E-31R1				7/12/49	0.56	315	
7S/1W-21P2			Irrigation and domestic	10/ 3/49	0.56	300					8/25/49	0.85	310	
											5/15/49	0.56	340	
7S/1W-22G1		390	Irrigation	9/21/49	0.28	230	7S/1E-32B2		400		7/12/49	0.56	295	
7S/1W-23J1			Irrigation	5/18/49	1.13	370					8/25/49	0.28	290	
				10/ 4/49	0.56	350					5/15/49	0.28	270	
7S/1W-23P1			Irrigation	5/18/49	0.56	250	7S/1E-32R1				7/13/49	0.28	255	
7S/1W-24H2			Irrigation	5/17/49	0.85	490					8/25/49	0.28	280	
				8/26/49	0.85	430					10/ 4/49	0.28	270	
7S/1W-25E1			Irrigation	5/15/49	0.56	340					10/ 4/49	0.56	310	
				7/12/49	0.56	295	7S/1E-33Q2							
				8/25/49	0.56	310								
7S/1W-27A1			Irrigation	5/19/49	0.85	335	7S/1E-35G2				5/11/49	0.85	400	
7S/1W-28G1			Irrigation and domestic	5/19/49	0.85	290					8/25/49	0.56	370	
				10/ 3/49	0.56	270					10/ 4/49	0.56	350	
7S/1W-29K1		1065	Irrigation	5/18/49	0.85	335	7S/1E-36L2				5/11/49	1.41	520	
				7/12/49	0.56	285					9/20/49	1.13	430	
				8/26/49	0.56	320	7S/1E-7K3				5/12/49	1.67	730	
7S/1W-29M2		607		9/ 7/49	0.28	250					9/26/49	1.41	550	
7S/1W-30G1			Irrigation	9/20/49	0.56	300	7S/1E-18H1		400	Irrigation	5/12/49	1.41	630	
7S/1W-31A3			Irrigation	9/ 2/49	0.56	270					9/20/49	1.41	550	
7S/1W-32K2		202	Irrigation and domestic	5/19/49	0.85	265	7S/2E-19F4				10/ 5/49	1.13	460	
				9/20/49	0.28	240	7S/2E-20C1		327	Irrigation and domestic	10/ 4/49	1.13	500	
7S/1W-34D1			Irrigation	5/18/49	0.85	290								
				9/18/49	0.28	220	8S/1W-1N1		775	Irrigation	5/17/49	2.82	560	
7S/1W-34P1				5/17/49	0.85	370	8S/1W-3D1		818		5/17/49	1.13	350	
				7/14/49	0.56	315					9/21/49	1.67	400	
				9/22/49	0.85	370	8S/1W-10M1				5/17/49	1.13	380	
7S/2W-1D1			Irrigation and domestic	5/11/49	1.13	405					10/ 3/49	1.97	460	
				9/ 6/49	0.85	230	8S/1W-12M1		290	Irrigation	5/17/49	1.97	560	
7S/2W-1G2			Irrigation and domestic	5/17/49	0.85	340					9/26/49	2.82	620	
				8/23/49	0.85	370	8S/1W-15B1		144	Irrigation	5/17/49	1.13	380	
7S/2W-2P1		205	Irrigation	5/17/49	0.56	340					7/12/49	0.85	350	
				9/ 6/49	0.56	290	8S/1W-16K1				7/12/49	0.85	350	
7S/2W-3A1		550		5/17/49	0.85	380								
				8/23/49	0.56	280								
7S/2W-3E1			Irrigation	9/20/49	0.56	270								
7S/2W-3K1		770	Irrigation	8/ 3/49	0.85	315								
7S/2W-4H1			Domestic	5/19/49	0.85	290	8S/1E-1H1				5/11/49	1.13	560	
7S/2W-11G2			Irrigation	5/17/49	0.56	365					10/ 4/49	1.13	430	
				9/23/49	0.56	300	8S/1E-1Q1		120	Irrigation and domestic	5/11/49	0.85	580	
7S/2W-11R1		552	Irrigation	5/17/49	0.56	380					9/20/49	0.85	460	
				9/ 8/49	0.85	370					9/21/49	1.13	470	
				9/20/49	0.85	370	8S/1E-3N1		176	Irrigation	10/ 4/49	0.28	270	
7S/2W-12K1		510	Irrigation	5/17/49	1.13	420					5/15/49	0.56	315	
				9/ 6/49	0.85	370	8S/1E-6N2		400	Irrigation	5/15/49	0.85	290	
7S/2W-14G1		500	Irrigation	10/ 3/49	0.85	370					9/ 7/49	0.28	250	
7S/2W-14H2		1405	Irrigation	5/19/49	1.41	570	8S/1E-8A1				5/12/49	0.56	250	
7S/1E-2B1			Irrigation	9/ 6/49	2.54	690					8/24/49	0.28	240	
7S/1E-7R1		865	Municipal	10/ 5/49	0.56	260	8S/1E-9H1		245	Irrigation	10/ 4/49	0.28	290	

PARTIAL MINERAL ANALYSES OF GROUND WATERS IN SANTA CLARA VALLEY—Continued

Well number		Depth, in feet	Use	Date of sample	Chlo- rides, in epm	Solids, in ppm	Well number		Depth, in feet	Use	Date of sample	Chlo- rides, in epm	Solids, in ppm
Division of Water Resources	Poland*						Division of Water Resources	Poland*					
8S/1E-9J1		183	Irrigation	5/15/49	1.67	630	9S/3E-22P1		209	Irrigation	5/13/49	0.85	380
8S/1E-10J2			Irrigation	5/12/49	3.10	900					9/ 8/49	0.28	330
				7/ 7/49	2.26	650	9S/3E-23F1			Irrigation	10/ 4/49	0.56	310
8S/1E-11C1		180	Irrigation	5/12/49	0.56	500	9S/3E-26B1			Irrigation	5/13/49	0.85	315
				7/ 7/49	1.13	430					7/ /49	0.85	315
				9/26/49	0.85	400					10/ 4/49	0.56	260
8S/1E-13A1			Irrigation	5/12/49	0.85	430	9S/3E-26N3			Irrigation	5/13/49	0.28	340
				10/ 4/49	0.85	310					9/19/49	0.56	280
8S/1E-14G1			Irrigation	9/ 7/49	3.38	680	9S/3E-29B1			Abandoned	10/ 4/49	0.28	250
8S/1E-17R3			Irrigation and domestic	9/ 7/49	1.41	470	9S/3E-32N1		67	Irrigation and domestic	5/13/49	0.56	340
											9/ 2/49	0.28	290
8S/1E-21B1				5/12/49	0.85	430	9S/3E-35N1			Irrigation	5/12/49	0.56	270
		48		8/24/49	0.56	330			179		7/ /49	0.28	235
8S/1E-25M1			Irrigation and domestic	5/11/49	0.85	400	9S/3E-35Q1			Irrigation	8/23/49	0.28	220
8S/1E-25M2			Irrigation	9/ 7/49	0.85	330	9S/3E-36F1			Irrigation and domestic	9/ 2/49	0.56	230
		20		5/11/49	0.56	230			340	Irrigation	5/13/49	0.56	270
				10/ 3/49	0.85	300	10S/3E-1L1			Irrigation	5/12/49	0.85	315
8S/1E-26H1			Irrigation	5/11/49	0.28	210	10S/3E-2L2			Irrigation	9/30/49	0.28	250
		203		8/24/49	0.85	250			220	Irrigation and domestic	5/12/49	0.56	350
8S/2E-7A3			Irrigation	5/11/49	0.56	350	10S/3E-3C2				9/ 2/49	0.28	290
				9/ 6/49	0.56	320			55	Irrigation	5/12/49	0.56	210
8S/2E-8M1		200	Irrigation	5/11/49	0.56	370	10S/3E-9E1			Irrigation, stock and domestic	5/13/49	0.56	290
				9/20/49	0.56	290	10S/3E-12D1				10/ 4/49	0.56	230
8S/2E-17B2			Irrigation	5/11/49	0.56	350			182	Irrigation	5/12/49	0.56	270
		220		9/ 6/49	0.28	280	10S/3E-13J1				10/ 4/49	0.28	210
8S/2E-17J2			Irrigation	5/10/49	0.58	380				Irrigation	5/12/49	0.56	300
		170		9/26/49	0.28	280	10S/3E-14B1		175		7/ /49	0.85	295
8S/2E-18E1			Irrigation	5/11/49	0.85	420					9/30/49	0.56	250
				9/ 7/49	0.56	350	10S/3E-25K1			Irrigation	5/12/49	0.56	300
8S/2E-21B1		100	Irrigation	5/10/49	0.56	320			289		7/ /49	0.56	265
				9/ 6/49	0.28	260	10S/3E-35J1				8/23/49	0.56	260
8S/2E-22D1			Irrigation and domestic	5/10/49	0.56	270					5/12/49	1.97	670
		140		9/ 8/49	0.28	290	10S/3E-36C1		250	Irrigation	8/23/49	1.97	570
8S/2E-26D1			Irrigation and domestic	5/10/49	0.56	450					5/12/49	0.56	320
				9/ 6/49	0.56	350	10S/4E-7B2		185	Irrigation	9/ 8/49	0.85	340
8S/2E-26M2		150	Irrigation	5/10/49	0.28	350					5/13/49	0.85	520
				10/ 4/49	0.56	320	10S/4E-17E2			Irrigation and domestic	10/ 4/49	1.13	420
8S/2E-31E4			Irrigation	5/11/49	1.13	380			185		5/12/49	1.13	380
		30		8/24/49	0.56	300	10S/4E-18G2			Irrigation and domestic	8/24/49	0.85	330
8S/2E-31L1			Irrigation and domestic	5/11/49	0.28	230					5/13/49	0.56	300
		150		9/ 7/49	0.56	300			210	Irrigation and domestic	7/ /49	0.28	265
8S/2E-34R1			Irrigation	5/10/49	0.56	380	10S/4E-20J1				10/ 4/49	0.56	240
				8/24/49	0.56	330			412	Irrigation	5/11/49	0.85	420
8S/2E-35E3				5/10/49	0.56	350					8/23/49	1.13	430
				9/ 6/49	0.56	300	10S/4E-27B1				7/ /49	0.85	280
8S/2E-35Q1			Irrigation and domestic	5/16/49	0.56	370			322	Irrigation	8/23/49	1.13	370
				9/ 2/49	0.56	320	10S/4E-28K2				5/11/49	0.85	520
9S/2E-1K2			Irrigation	5/16/49	0.56	370					8/23/49	1.13	430
		125		9/ 2/49	0.56	330	10S/4E-28N2		447	Irrigation	5/11/49	0.85	320
9S/2E-12H1			Irrigation	5/16/49	0.56	330					7/ /49	0.85	280
				9/ 8/49	0.28	260	10S/4E-29D1				8/23/49	1.13	430
9S/3E-4B1				5/13/49	0.28	350			220	Irrigation and domestic	5/11/49	0.28	315
				9/ 2/49	0.56	290	10S/4E-30J3				8/23/49	0.56	270
9S/3E-7C1			Irrigation	5/16/49	0.56	320					5/11/49	0.56	300
		170		9/ 2/49	0.56	310	10S/4E-31H2		103	Irrigation and domestic	7/ /49	0.56	265
9S/3E-7F1			Irrigation	5/16/49	0.56	380					8/24/49	0.28	250
				10/ 3/49	0.56	330	10S/4E-35E1		447	Irrigation and domestic	5/12/49	0.56	270
9S/3E-9R1		180	Irrigation	10/ 4/49	0.56	390					8/23/49	0.28	240
				5/16/49	5.08	800	10S/4E-35Q1				5/12/49	0.56	270
9S/3E-9R2			Irrigation	5/13/49	0.56	450			447	Irrigation	8/23/49	0.28	240
		235		9/ /49	0.85	370					5/11/49	0.85	420
9S/3E-15R2				10/ 4/49	0.56	330	11S/3E-1Q1		103		10/ 4/49	0.85	360
				10/ 4/49	0.56	330					7/ /49	1.13	500
9S/3E-16C2			Irrigation	5/16/49	0.56	380	11S/4E-1B1				5/11/49	0.56	300
9S/3E-16C3				8/30/49	0.56	330	11S/4E-3G1		220	Irrigation	5/11/49	0.56	320
				5/16/49	0.85	420	11S/4E-3N3				5/11/49	1.67	780
9S/3E-16G1		301	Irrigation and domestic	9/ 2/49	1.13	350					9/ 8/49	1.41	700
				5/13/49	0.56	315	11S/4E-3R2		220	Irrigation	5/11/49	1.13	460
9S/3E-16M1			Irrigation	7/ /49	0.56	295					9/ 2/49	1.13	430
		425		10/ 4/49	0.85	340	11S/4E-4K4			Irrigation	5/11/49	0.56	440
9S/3E-16R2				5/16/49	0.56	340							
9S/3E-17C1			Irrigation and domestic	10/ 4/49	0.85	310							
9S/3E-21H2													
9S/3E-22F3				10/ 4/49	0.56	340							

PARTIAL MINERAL ANALYSES OF GROUND WATERS IN SANTA CLARA VALLEY—Continued

Well number		Depth, in feet	Use	Date of sample	Chlo- rides, in epm	Solids, in ppm	Well number		Depth, in feet	Use	Date of sample	Chlo- rides, in epm	Solids, in ppm
Division of Water Resources	Poland*						Division of Water Resources	Poland*					
11S/4E-4N1-----			Irrigation-----	5/10/49	0.56	340	11S/4E-11J1-----		598	Irrigation-----	5/11/49	1.13	420
11S/4E-5D1-----			Irrigation-----	8/23/49	0.56	310	11S/4E-13B1-----		673	Irrigation-----	8/31/49	0.85	370
11S/4E-6N1-----		178	Irrigation-----	5/12/49	0.56	320					5/11/49	2.82	580
11S/4E-7G2-----			Irrigation-----	8/23/49	0.56	260					7/ /49	2.26	540
11S/4E-7R1-----			Irrigation-----	5/12/49	0.56	220	11S/4E-16L1-----		130	Irrigation-----	9/ 8/49	2.54	500
11S/4E-8L1-----			Irrigation-----	8/ 3/49	0.28	200					5/10/49	0.85	500
11S/4E-9A2-----		77	Irrigation-----	5/12/49	0.28	250	11S/4E-17A1-----		280	Irrigation-----	8/23/49	0.56	310
11S/4E-9G1-----			Irrigation-----	8/23/49	0.28	210					5/10/49	0.56	340
11S/4E-9P3-----			Irrigation-----	5/11/49	0.56	250	11S/4E-17F1-----		406	Irrigation-----	8/23/49	0.28	290
11S/4E-10L1-----		71	Irrigation-----	5/10/49	0.85	320	11S/4E-17Q2-----		183	Irrigation-----	5/10/49	0.28	260
11S/4E-11C1-----			Irrigation-----	9/ 8/49	0.56	310	11S/4E-21H1-----		90	Irrigation-----	5/11/49	0.28	315
			Irrigation-----	5/11/49	0.56	730	11S/4E-22B1-----		350	Irrigation-----	5/10/49	0.56	570
		60	Irrigation-----	9/ 8/49	0.56	600					5/10/49	1.13	380
			Irrigation-----	5/11/49	1.13	520	11S/4E-22D1-----		185	Irrigation-----	9/ 8/49	0.56	290
			Irrigation-----	8/23/49	0.56	460					7/ /49	0.85	300
			Irrigation-----	5/10/49	0.85	450	11S/4E- 8J1-----		300	Irrigation-----	8/30/49	0.28	240
		220	Irrigation-----	9/ 1/49	0.56	310					7/ /49	0.56	350
			Irrigation-----	5/11/49	1.13	600	11S/4E-29G1-----		120	Irrigation-----	8/30/49	0.28	290
			Irrigation and domestic	8/31/49	1.13	430					5/10/49	0.85	380
				5/11/49	0.85	460	11S/4E-33N1-----		190	Irrigation-----	8/30/49	0.28	290
				8/ 3/49	0.85	370					5/10/49	2.26	490
											9/ 2/49	1.67	400

* Samples collected and analyzed in 1938-39 as a program of Stanford University, Geology Department, under direction of Joseph F. Poland.

APPENDIX H

**APPLICATIONS TO APPROPRIATE WATER
IN SANTA CLARA VALLEY**

(Filed with Division of Water Resources, Department of Public Works, under provisions of
Water Code, State of California)

**APPLICATIONS TO APPROPRIATE WATER IN SANTA CLARA VALLEY, FILED WITH DIVISION OF WATER RESOURCES,
DEPARTMENT OF PUBLIC WORKS, UNDER PROVISIONS OF WATER CODE, STATE OF CALIFORNIA**

Applica- tion num- ber	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian					Amount of diversion		Purpose	Status
				¼	¼	Sec- tion	Town- ship	Range	Second- feet	Acre- feet		
232	3/20/16	Aloise McPhee.....	Glenovia Creek.....	SE	SW	6	10S	2E	0.04		Irrigation and do- mestic	License
649	4/23/17	A. Lantz.....	Arroyo Seco.....		SW	25	8S	1E	0.075		Irrigation.....	License
1733	3/23/20	Lester, Gilker, and Lester.....	Los Gatos Creek.....		SW	10	8S	1W	3.5			License
2153	12/23/20	San Jose Abstract and Title Company.....	Los Gatos.....	SE	Proj.	16	8S	1W	2.22		Irrigation.....	License
3323	3/24/23	M. Kell.....	Uvas Creek.....	SE	NW	18	10S	3E	0.27		Irrigation and do- mestic	License
4698	7/14/25	Montezuma Mountain Ranch School.....	Collins Creek.....	NE	NW	7	9S	1W	0.13		Irrigation and do- mestic	License
5156	4/23/30	City of San Jose.....	N. Fork Penitencia Creek.....	NW	SE	21	6S	2E		500	Irrigation.....	License
5653	12/ 1/26	Santa Clara Valley Water Conservation District	Guadalupe Creek.....	NE	SW	9	8S	1E		10,000	Irrigation and do- mestic	Permit
5654	12/ 1/26	Santa Clara Valley Water Conservation District	Los Gatos.....	SW	SW	9	8S	1E		10,000	Irrigation and do- mestic	Permit
6167	1/19/26	I. Meyerholz, et al.....	Stevens Creek.....	NE	SE	3	8S	1W			Irrigation.....	License
6296	5/22/29	Board of Trustees Stanford University.....	Los Trancos Creek.....	SE	NE	10	2S	2W	2.34		Irrigation.....	License
6601	3/15/30	L. O'Neal.....	Unnamed stream.....	SW	NE	28	6S	3W	40	900	Irrigation and do- mestic	License
6753	7/29/30	California Water Service Company.....	San Francisquito Creek.....	SE	SW	10	7S	3W	8,500	g.p.d.	Irrigation and do- mestic	License
7140	12/ 9/31	Santa Clara Valley Water Conservation District	Coyote Creek.....	NW	SE	12	6S	4W	25	980	Municipal.....	Permit
7141	12/ 9/31	Santa Clara Valley Water Conservation District	Coyote Creek.....	SE	SE	29	9S	4E		40,000	Irrigation and do- mestic	Permit
7141	12/ 9/31	Santa Clara Valley Water Conservation District	Almaden Creek.....	NW	NE	11	9S	1E		2,500	Irrigation and do- mestic	License
7142	12/ 9/31	Santa Clara Valley Water Conservation District	Guadalupe Creek.....	NE	NE	32	8S	1E		3,500	Irrigation and do- mestic	License
7143	12/ 9/31	Santa Clara Valley Water Conservation District	Stevens Creek.....	NE	NE	32	8S	1E		3,500	Irrigation and do- mestic	License
7438	11/16/32	Grant Company.....	Arroyo Aguague.....	NW	NW	27	7S	2W		4,000	Irrigation and do- mestic	License
7913	4/20/34	G. Smith.....	Uvas Creek.....	SE	NW	12	7S	2E		500	Irrigation.....	License
7995	6/28/24	C. Miller, et al.....	Uvas Creek.....	SW	SE	Proj. 17	10S	3E	0.11		Irrigation and do- mestic	License
8013	7/ 6/34	J. Marchetti.....	Calero.....	NW	NE	36	8S	1E	1.0		Irrigation.....	License
8079	8/21/24	F. J. Polak.....	Uvas Creek.....	NE	SW	17	10S	3E	0.3		Irrigation.....	License
8098	9/11/34	Santa Clara Valley Water Conservation District	Coyote River.....	SW	SE	6	9S	3E	5.0		Irrigation.....	License
8099	9/11/34	Santa Clara Valley Water Conservation District	Calero.....	NW	NE	6	9S	2E		3,500	Irrigation and do- mestic	License
8387	7/10/35	Santa Clara Valley Water Conservation District	Almaden Creek.....	NW	NE	11	9S	1E	100	6,000	Irrigation and do- mestic	License
8388	7/10/35	Santa Clara Valley Water Conservation District	Los Gatos Creek.....	NE	SE	9	8S	1W		4,000	Irrigation and do- mestic	Permit
8462	10/ 3/35	Santa Clara Valley Water Conservation District	Coyote River.....	NE	SW	16	8S	2E		5,000	Irrigation and do- mestic	License
9579	5/ 9/39	F. G. Wool Packing.....	Coyote River.....	SW	NE	22	7S	1E	0.47		Irrigation.....	License
		Aloise McPhee.....	Swanson Creek.....	NE	NE	12	10S	1E	0.3		Irrigation, domestic and fire protection	Permit
11010	3/20/45	Santa Clara Valley Water Conservation District	Penitencia Creek.....	SE	SW	23	6S	1E		3,500	Irrigation and do- mestic	Permit
11549	9/12/46	A. Fries.....	Arroyo Aguague.....	SW	SW	10	7S	2E	1,650	g.p.d.	Irrigation and stock	License
11574	10/ 3/46	C. B. and G. B. Kuhn.....	Unnamed creek.....	SE	SE	22	7S	2E		1	Irrigation.....	License
			Unnamed spring No. 1.....	NW	NW	27	7S	2E	5,760	g.p.d.		
			Unnamed spring No. 2.....	SE	NE	27	7S	2E	5,760	g.p.d.		
			Unnamed spring No. 3.....	SE	NE	27	7S	2E	38,880	g.p.d.		
			Unnamed spring No. 4.....	NE	NE	27	7S	2E	7,200	g.p.d.		
			Unnamed spring No. 5.....	SE	SE	22	7S	2E	5,760	g.p.d.		
			Unnamed spring No. 6.....	SE	SE	22	7S	2E	7,200	g.p.d.		
			Unnamed spring No. 7.....	SE	SE	22	7S	2E	1,440	g.p.d.		
11599	10/31/46	E. S. Selvage.....	Two unnamed streams.....	NW	NE	22	10S	3E	0.75	30	Irrigation.....	Permit
			Two unnamed streams.....	SW	NE	22	10S	3E				
			Two unnamed streams.....	NW	SE	22	10S	3E				

APPLICATIONS TO APPROPRIATE WATER IN SANTA CLARA VALLEY, FILED WITH DIVISION OF WATER RESOURCES,
DEPARTMENT OF PUBLIC WORKS, UNDER PROVISIONS OF WATER CODE, STATE OF CALIFORNIA—Continued

124

Applica- tion num- ber	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian					Amount of diversion		Purpose	Status
				¼	¼	Sec- tion	Town- ship	Range	Second- feet	Acre- feet		
11600	10/31/46	E. S. Selvage	Two unnamed streams	NW	SE	22	10S	3E	0.3	25	Irrigation	Permit
			Two unnamed streams	SW	SE	22	10S	3E				
			Two unnamed streams	SE	SE	22	10S	3E				
11601	10/31/46	E. S. Selvage	Unnamed stream	NW	SW	22	10S	3E	0.083	6.0	Irrigation and do- mestic	License
11727	2/13/47	B. Cribari and Sons	Unnamed stream	NE	NE	34	7S	2E		10	Irrigation	Permit
11751	3/ 3/47	Santa Clara Valley Water Conservation District	Los Gatos Creek	SE	SE	29	8S	1W		30,000	Irrigation and do- mestic	Permit
11806	4/ 1/47	H. Riedel, et al.	Dry Creek	NE	NW	19	2S	2E	0.5		Irrigation	Permit
11825	4/16/47	State Division of Forestry	Los Alamitos Creek	NE	NW	2	9S	1E	15,000	g.p.d.	Domestic and fire protection	License
12066	6/15/50	Chemketa Park Mutual Water Company	Moddy Gulch	SW	NW	9	9S	1W	0.04		Domestic	License
12134	10/20/47	San Jose Water Works	Saratoga (Campbell) Creek	SE	NW	11	8S	2W	1.96		Domestic, municipal, industrial	Permit
12201	7/21/47	E. Weld	Silver Creek	SW	NW	30	7S	2E		11	Irrigation	Permit
			Unnamed stream	NE	SE	25	7S	1E		1	Stockwater	
12208	12/22/47	C. B. and G. B. Kuhn	Unnamed spring			27	7S	2E	7,200	g.p.d.	Irrigation and stock- water	Permit
13016	4/ 4/49	Santa Clara Valley Water Conservation District	Coyote Creek	SW	NE	10	9S	3E		75,000	Irrigation, domestic and industrial	Permit
13020	4/ 5/49	R. V. and E. S. Garrod	Unnamed creek	NE	SE	34	7S	2W		5	Irrigation and do- mestic	Permit
13021	4/ 5/49	E. I. and L. B. Poor	Unnamed creek	NW	SE	34	7S	2W		5	Irrigation and do- mestic	Permit
13223	7/ 8/49	George Britton	Unnamed stream	SW	SW	5	10S	3E		10	Irrigation and stock	Permit
13224	7/ 8/49	George Britton	Unnamed stream	SE	SW	5	10S	3E		50	Irrigation, stock and domestic	Permit
13352	9/14/49	P. Peabody	Unnamed creek	SW	SW	23	10S	4E		56	Irrigation and stock	License
13375	10/ 3/49	F. Metzger	Dry Creek	NW	SW	34	7S	2E		4.5	Irrigation	Permit
13409	10/21/49	N. W. and P. H. Mancuso	Unnamed ravine	NW	NE	15	7S	2E	15,000	g.p.d.	Irrigation and do- mestic	Permit
13444	11/ 4/49	J. A. Besson, Et ux.	Bodfish Creek	SW	NE	Proj. 5	11S	3E	1.0	100.0	Irrigation and do- mestic	Permit
13584	2/16/50	G. and R. Mancuso	Unnamed ravine	NE	NE	28	7S	2E		10	Irrigation	Permit
13641	3/21/50	P. Peabody	Unnamed spring	SW	SW	23	10S	4E		20	Irrigation	Permit
13719	5/ 3/50	B. Greef	Eastman Creek	SW	SE	12	10S	2E	0.16	30.0	Irrigation and do- mestic	Permit
13791	6/14/50	South Santa Clara Valley Water Conserva- tion District	Llagas Creek	SW	SW	30	9S	3E		7,500	Irrigation and do- mestic	Permit
13886	8/ 8/50	South Santa Clara Valley Water Conserva- tion District	Uvas Creek	SE	SE	12	10S	2E	100	30,000	Irrigation and do- mestic	Permit
13892	8/11/50	Santa Clara Valley Water Conservation District	Silver Creek	NE		32	7S	2E		2,000	Domestic	Incomplete
13900	8/17/50	F. M. and C. M. Shay	Uvas Creek	NW	SW	28	10S	3E	2,000	g.p.d.	Domestic and stock	Permit
13970	9/29/50	Ruth M. Weston	Uvas Creek	SE	NE	29	10S	3E	0.250		Irrigation	Permit
14013	10/23/50	Fred O. Scheidegger	Little Uvas Creek	SW	NE	34	9S	2E	0.25		Irrigation	Permit
14021	10/26/50	R. H. Bickel	Uvas Creek	NW	NW	33	10S	3E	0.25		Irrigation and do- mestic	Permit
			Uvas Creek	SW	NW	33	10S	3E	0.085		Irrigation and do- mestic	Permit
			Uvas Creek	NW	NW	33	10S	3E	0.67		Irrigation and do- mestic	Permit
14037	11/ 8/50	W. Quadros	Dry Creek	NW	NW	15	7S	2E	1,500	g.p.d.	Irrigation and do- mestic	Permit
14111	12/26/50	A. Tomkin	Little Uvas Creek	SE	SW	28	9S	2E	0.38		Irrigation	Permit
14140	1/25/51	J. Lowe	Little Uvas Creek	SW	SE	35	9S	2E		40	Irrigation	Permit
14163	2/16/51	R. Holland	Little Uvas Creek	NW	NE	32	9S	2E	0.175		Irrigation	Permit

SANTA CLARA VALLEY INVESTIGATION

APPLICATIONS TO APPROPRIATE WATER IN SANTA CLARA VALLEY, FILED WITH DIVISION OF WATER RESOURCES,
DEPARTMENT OF PUBLIC WORKS, UNDER PROVISIONS OF WATER CODE, STATE OF CALIFORNIA—Continued

Applica- tion num- ber	Date filed	Name of applicant	Source of water supply	Location of diversion point, referenced to Mt. Diablo base and meridian					Amount of diversion		Purpose	Status
				¼	¼	Sec- tion	Town- ship	Range	Second- feet	Acre- feet		
14170	2/23/51	Henry Fred Gerdtz	Dry Creek	SE	SW	Proj. 28	7S	2E		8.7	Irrigation	Permit
14288	5/ 2/51	J. DeBell	Bodfish Creek	NE	SW	3	11S	3E		138	Irrigation and rec- reation	Permit
14313	5/17/51	California Water Service Company	San Francisquito Creek	NE	NW	14	6S	4W	75	2,500	Municipal	Permit
14468	9/ 6/51	G. Bender	Dry Creek	NE	NE	29	7S	2E	0.2	3	Irrigation	Permit
14503	9/27/51	F. M. and C. M. Shay	Uvas Creek	NW	SW	Proj. 28	10S	3E	0.09	g.p.d. 5.5	Irrigation and stock	Permit
14587	11/26/51	I. Klarich	Swiss Creek	SW	NW	28	7S	2W	85,000		Irrigation	Permit
14655	1/25/52	F. Metzger	Dry Creek	NW	SW	34	7S	2E			Irrigation	Permit
14687	2/26/52	G. Smith	Uvas Creek	SW	SE	17	10S	3E	0.11		Irrigation and do- mestic	Permit
14922	7/22/52	C. Swenson	Silver Creek	SE	NE	25	7S	1E	0.33		Irrigation	Permit
15081	11/14/52	Blacks Almaden Water System	Los Alamitos Creek	SW	SE	Proj. 10	9S	1E	3		Domestic, municipal and industrial	Permit
15144	1/ 5/53	V. Guluzzo	Unnamed spring	NE	NE	7	7S	2E	0.39		Irrigation	Permit
15349	5/18/53	F. M. and Cecilia M. Shay	Uvas Creek			Proj. 28	10S	3E	0.04		Domestic and stock- water	Permit
15412	7/14/53	San Jose Water Works	Saratoga (Campbell) Creek	SE	NW	11	8S	2W		2,000	Domestic, municipal and industrial	Pending
15547	9/21/53	Anthony and Carmelita Peters	Unnamed ravine	NW	NW	Proj. 15	7S	2E		5	Irrigation	Permit
15817	4/ 6/54	Donald Williams	Unnamed stream			Proj. 4	7S	2E	0.11		Irrigation	Permit
16146	11/19/54	E. P. Hockenbeamer	Unnamed stream			Proj. 34	10S	3E	0.75		Irrigation	Pending

APPENDIX I

DAMS UNDER STATE SUPERVISION IN AND ADJACENT
TO SANTA CLARA VALLEY, 1954

DAMS UNDER STATE SUPERVISION IN AND ADJACENT TO SANTA CLARA VALLEY, 1954

Name	Owner	Stream	Location M. D. B. & M.			Type	Crest length, in feet	Crest height, in feet	Crest eleva- tion, in feet	Capac- ity, in acre- feet	Date con- structed	Use
			Sec- tion	Town- ship	Range							
Almaden	Santa Clara Valley Water Conser- vation District	Alamitos Creek	11	9S	1E	Earth	500	110	615	2,000	1936	Irrigation, domestic
Anderson	Santa Clara Valley Water Conser- vation District	Coyote River	10	9S	3E	Earth	1,200	235	640	75,000	1950	Irrigation, domestic, in- dustrial
Austrian	San Jose Water Works	Los Gatos Creek	24	9S	1W	Earth	700	185	1,125	6,140	1950	Domestic
Calero	Santa Clara Valley Water Conser- vation District	Calero Creek	6	9S	2E	Earth	845	94	490	9,300	1935	Irrigation, domestic
Cherry Flat	City of San Jose	Penitencia Creek	21	6S	2E	Earth	230	60	1,700	500	1936	Irrigation
Coyote	Santa Clara Valley Water Conser- vation District	Coyote Creek	16	8S	2E	Earth, rock	980	140	803	27,770	1936	Irrigation, domestic
Coyote Percolation	Santa Clara Valley Water Conser- vation District	Coyote Creek	29	9S	4E	Concrete sill, flash- boards	204	24	238	72	1934	Irrigation, domestic
DeBell	Jack DeBell	Tributary of Bodfish Creek	3	11S	3E	Earth	616	53	493	120	1952	Irrigation, recreation
Elmer J. Chesbro	South Santa Clara Valley Water Conservation District	Llagas Creek	30	9S	3E	Earth, rock	650	95	535	7,500	Under con- struction 1930	Irrigation, domestic
Felt Lake	Leland Stanford Jr. University	Tributary of Los Trancos Creek	22	6S	3W	Earth	590	67	367	900	1930	Irrigation, domestic
Grant Company No. 2	Grant Ranch	Arroyo Aguague	2	7S	2E	Earth	80	27	1,596	600	1927	Irrigation
Guadalupe	Santa Clara Valley Water Conser- vation District	Guadalupe Creek	32	8S	1E	Earth	695	142	623	3,500	1935	Irrigation, domestic
Higvera	Marion Cortner Weller	South Calera Creek	32	5S	1E	Earth	515	44	195	81	1953	Irrigation
Kuhn	Charles B. and George B. Kuhn	Tributary of Dry Creek	27	7S	2E	Earth	312	67	760	85	1947	Irrigation
Lagunita	Leland Stanford Jr., University	Tributary of San Francisco Bay	10	6S	3W	Earth	2,500	15	134	260	1900	Irrigation, reclamation
Lake Ranch (east)	San Jose Water Works	Beardsley Creek	23	8S	2W	Earth	160	38	1,809	323	1877	Domestic
Lexington	Santa Clara Valley Water Conser- vation District	Los Gatos Creek	29	8S	1W	Earth	685	205	665	25,000	1953	Irrigation, domestic
Lower Howell	San Jose Water Works	Rundell Creek	31	8S	1W	Earth	475	38	1,387	153	1877	Domestic
North Fork	Pacheco Pass Water District	Pacheco Creek	22	10S	6E	Earth	600	100	483	6,150	1939	Irrigation
Peabody	Porter T. Peabody	Tributary of Llagas Creek	23	10S	4E	Earth	296	64	650	76	1950	Irrigation
Rickey	J. H. Rickey	Peter's Creek	22	7S	3E	Earth	175	64	104	47	1950	Irrigation
Selvage No. 2	Eugene G. Selvage	Tributary of Llagas Creek	22	10S	3E	Earth	440	42	400	24	1948	Irrigation, domestic
Stevens Creek	Santa Clara Valley Water Conser- vation District	Stevens Creek	27	7S	2W	Earth	1,080	120	545	4,000	1935	Irrigation, domestic
Upper Howell	San Jose Water Works	Rundell Creek	31	8S	1W	Earth	640	36	1,412	243	1878	Domestic
Vasona Percolating	Santa Clara Valley Water Conser- vation District	Los Gatos Creek	10	8S	1W	Earth	980	32	305	660	1935	Irrigation, domestic
Williams	San Jose Water Works	Los Gatos Creek	30	9S	1E	Gravity straight	87	70	1,222	160	1895	Domestic

APPENDIX J

RECORDS OF APPLICATION OF GROUND WATER TO
REPRESENTATIVE CROPS IN SANTA CLARA VALLEY

TABLE OF CONTENTS

RECORDS OF APPLICATION OF GROUND WATER TO
REPRESENTATIVE CROPS IN SANTA CLARA VALLEY

	<i>Page</i>
Application of Ground Water to Representative Crops in North Santa Clara Valley, Pressure Zone-----	133
Application of Ground Water to Representative Crops in North Santa Clara Valley, Forebay Zone-----	135
Application of Ground Water to Representative Crops in South Santa Clara Valley, Pressure Zone-----	136
Application of Ground Water to Representative Crops in South Santa Clara Valley, Forebay Zone-----	137

Pressure Zone

Crop	Season	Map number	Well number	Method of irrigation	Acres	Depth per irrigation, in inches										Total depth, in inches
						1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	
Alfalfa	1948	1	7S/1E-14C2	Check	30	2.31	8.59	9.41	7.67	8.50						36.48
	1949	2	7S/1E-11G1	Border check	6	6.46	3.80	7.80	4.06	3.74	5.10					30.96
						Weighted mean depth: 1948-49 35.56 inches (2.96 feet)										
Beans	1948	3	6S/1W-26D1	Contour check	77	4.25	2.16	2.56	2.25							11.22
	1948	4	6S/1W-29C1	Furrow	19.75	7.42	8.66	7.82								23.90
	1948	5	6S/1W-36G1	Furrow	20											40.2
	1948	6	6S/1E-30M1	Furrow	10											13.32
	1949	7	6S/1E-30L1	Furrow	45	1.86	2.99	2.82	2.60							10.27
		6	6S/1E-30M1													
	1949	3	6S/1W-26D1	Furrow	72	5.48	3.09	6.15								14.72
		8	6S/1W-12M2													
	1949	9	6S/2W-24C1	Furrow	51	5.52	7.63	3.88	2.62							19.65
						Weighted mean depths: 1948 17.93 inches (1.49 feet) 1949 15.02 inches (1.25 feet) 1948-49 16.28 inches (1.36 feet)										
Berries	1948	6	6S/1E-30M1	Furrow	9											29.80
	1948	10	7S/1W-16H1	Contour check	4											44.51
	1949	11	6S/1W-11N1	Furrow	10											26.20
						Weighted mean depths: 1948 34.33 inches (2.86 feet) 1949 26.20 inches (2.18 feet) 1948-49 30.79 inches (2.57 feet)										
Orchard Apricots	1948	12	6S/2W-27F1	Furrow	2.5	2.94	3.15									6.09
	1948	13	6S/2W-29D2	Contour check	10	13.84	8.83	11.40								34.07
	1948	13	6S/2W-29D2	Contour check	17.5	13.84	11.40									25.24
	1948	14	7S/1W-6P1	Contour check	35	1.62	3.23	3.28	5.20							13.33
	1948	14	7S/1W-6P1	Contour check	65		4.10	4.17								8.27
	1948	15	7S/1W-7F1	Contour	14	7.50		6.48								13.98
	1948	15	7S/1W-7F1	Contour	16	7.50	4.17	6.48								18.15
	1949	16	6S/2W-36H2	Contour check	12	9.36	9.60									18.96
						Weighted mean depths: 1948 14.30 inches (1.19 feet) 1949 18.96 inches (1.58 feet) 1948-49 14.62 inches (1.22 feet)										
Cherries	1948	12	6S/2W-27F1	Furrow	1.5	3.62	3.42									7.04
	1948	10	7S/1W-16H1	Contour check	3	4.26	4.01									8.27
	1948	17	7S/2W-3A1	Contour check	24	6.89	7.08	7.53	10.24							31.

Forebay Zone

[illegible]

SANTA CLARA VALLEY INVESTIGATION

Pressure Zone

Crop	Season	Map number	Well number	Method of irrigation	Acres	Depth per irrigation, in inches										Total depth, in inches	
						1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th		
Alfalfa-----	1948	37	10S/4E-19N1	Flood by ditch...	15	3.43	2.74	3.47	1.35	2.88	2.61	2.61				19.09	
	1948	38	10S/4E-30A2	-----	18	3.45	6.71	10.25	10.25							30.66	
	1948	39	11S/4E-10A1	-----	33	6.40	5.10	5.29	4.62	3.42	3.45	2.66	2.79			33.73	
	1948	40	11S/4E-11J1	Border check....	35	4.25	3.94	2.66	2.71	2.66	2.33	1.96	1.76	0.90		23.17	
	1949	37	10S/4E-19N1	Border check....	18	3.94	3.67	4.10	3.76	2.32	3.14	3.15	3.10			27.18	
						Weighted mean depths: 1948 27.35 inches (2.28 feet) 1949 27.18 inches (2.27 feet) 1948-49 27.32 inches (2.28 feet)											
Barley-----	1948	38	10S/4E-30A2	-----	12	3.45	3.45			1948		6.90 inches (0.58 foot)				6.90	
						Weighted mean depth: 1948 6.90 inches (0.58 foot)											
Beans-----	1948	41	11S/4E-9A2	Flood by ditch...	26	10.48	13.20									23.68	
	1948	42	11S/4E-22B1	Flood by ditch...	80	4.58	1.11									5.69	
						Weighted mean depth: 1948 10.10 inches (0.84 foot)											
Berries-----	1948	43	10S/4E-19C1	Flume ditch----	3.5	47.30				1948		47.30 inches (3.94 feet)				47.30	
						Weighted mean depth: 1948 47.30 inches (3.94 feet)											
Orchard Mixed-----	1948	44	11S/4E-17C1	Flood by ditch...	10	6.10	11.30	5.98								23.38	
							Weighted mean depth: 1948 23.38 inches (1.95 feet)										
Prunes-----	1948	45	10S/4E-28E1	Basin check----	26	2.34	5.68	2.56	2.23	1948		12.81 inches (1.07 feet)				12.81	
						Weighted mean depth: 1948 12.81 inches (1.07 feet)											
Walnuts-----	1948	46	11S/4E-3L1	Contour check...	4	12.00										12.00	
	1949	47	11S/4E-21J2	Contour check...	90	6.53	4.03	4.36								14.92	
	1949	46	11S/4E-3L1	Contour check...	4	8.25										8.25	
						Weighted mean depths: 1948 12.00 inches (1.00 foot) 1949 14.64 inches (1.22 feet) 1948-49 14.53 inches (1.21 feet)											
Total Orchard							Weighted mean depths: 1948 15.37 inches (1.28 feet) 1949 14.64 inches (1.22 feet) 1948-49 14.86 inches (1.24 feet)										
Pasture-----	1948	37	10S/4E-19N1	Flood by ditch...	3	1.40	2.65	1.53	2.43	1.99	0.88					10.88	
	1948	38	10S/4E-30A2	-----	10	2.30	2.30	1.84	1.26	1.84	1.83	4.60	4.60			20.57	
	1948	48	10S/4E-30P4	Flood by ditch...	18	3.36	2.24	2.78	3.93	3.81	5.19	5.08	4.67	3.12	4.26	41.30	
						Additional irrigation: 11th, 2.86											
	1949	40	11S/4E-11J1	Border check....	35	3.26	2.30	2.44	1.86	1.77	1.99	2.14	2.38	2.38	2.60	23.12	
	1949	48	10S/4E-30P4	Rectangular check	18	3.45	4.72	4.87	4.28	2.97	2.49	2.89	3.37	5.07	3.17	46.63	
							Additional irrigation: 11th, 3.27; 12th, 2.41; 13th, 3.67 Weighted mean depths: 1948 31.67 inches (2.64 feet) 1949 31.10 inches (2.59 feet) 1948-49 31.31 inches (2.61 feet)										
Tomatoes-----	1948	42	11S/4E-22B1	Flood by ditch...	20	2.21	2.16	2.11	0.40							6.88	
	1949	46	11S/4E-3L1	Furrow-----	17	3.48	2.83	5.78	1.94	3.24	1.78					19.05	
						Weighted mean depths: 1948 6.88 inches (0.57 foot) 1949 19.05 inches (1.59 feet) 1948-49 12.47 inches (1.04 feet)											
Truck-----	1948	38	10S/4E-30A2	-----	8	7.20	17.50	8.13	10.17							43.00	
	1948	46	11S/4E-3L1	-----	15	10.09	7.58	5.33								23.00	
	1948	46	11S/4E-3L1	-----	10	9.60	3.77									13.37	
	1948	46	11S/4E-3L1	-----	13	8.24	7.62	5.44	3.00	2.22						26.52	
	1948	46	11S/4E-3L1	-----	12	10.45	3.21	3.67								17.33	
	1948	49	11S/4E-10Q1	-----	30	17.20										17.20	
	1948	49	11S/4E-10Q1	-----	14	8.90	10.83	8.18	9.42	5.74						43.07	
	1948	49	11S/4E-10Q1	-----	5	12.85	16.09	12.02								40.96	
	1948	49	11S/4E-10Q1	-----	30	32.40										32.40	
	1949	46	11S/4E-3L1	-----	10.5	7.58	7.25									14.83	
	1949	41	11S/4E-9A2	-----	26	15.2	11.3									26.50	
							Weighted mean depths: 1948 26.80 inches (2.23 feet) 1949 23.14 inches (1.93 feet) 1948-49 26.03 inches (2.17 feet)										

Forebay Zone

[illegible]

APPENDIX K

SEASONAL SUMMARIES OF MONTHLY YIELD STUDIES

TABLE OF CONTENTS
SEASONAL SUMMARIES OF MONTHLY YIELD STUDIES

	<i>Page</i>
Anderson Reservoir on Coyote Creek-----	141
Combined Operation of Alamitos Diversion and Lexington Reservoir on Los Gatos Creek -----	141
Little Francis Reservoir on San Francisquito Creek-----	142
Zayante Reservoir on Zayante Creek-----	142
Uvas Reservoir on Uvas Creek-----	143

SEASONAL SUMMARY OF MONTHLY YIELD STUDY, ANDERSON RESERVOIR ON COYOTE CREEK

(In acre-feet)

Storage capacity: 75,000 acre-feet

Seasonal yield: 56,000 acre-feet

Season	Water supply		Distribution of water supply					
	Storage, October 1	Coyote Creek inflow	Evaporation	Releases to			Spill	Storage, September 30
				Coyote Creek	Alamitos Percolation Pond	Dry Creek		
1935-36	0	54,300	400	44,800	6,400	2,700	0	0
36-37	0	62,800	1,100	48,900	4,600	3,600	0	4,600
37-38	4,600	151,400	2,700	58,900	7,300	4,500	31,500	51,100
38-39	51,100	20,300	600	52,000	17,900	900	0	0
1939-40	0	65,400	1,000	49,900	3,700	4,500	0	6,300
40-41	6,300	138,100	2,500	62,900	7,100	4,500	19,800	47,600
41-42	47,600	76,100	2,300	69,400	9,400	4,500	0	38,100
42-43	38,100	69,100	1,500	69,400	14,700	4,500	0	17,100
43-44	17,100	51,100	400	56,100	11,700	0	0	0
1944-45	0	51,700	300	45,500	5,000	900	0	0
45-46	0	37,900	0	37,900	0	0	0	0
46-47	0	9,000	0	9,000	0	0	0	0
47-48	0	4,800	0	4,800	0	0	0	0
AVERAGES		60,900	1,000	46,900	6,700	2,400	3,900	

SEASONAL SUMMARY OF MONTHLY YIELD STUDY, COMBINED OPERATION OF ALAMITOS DIVERSION AND LEXINGTON RESERVOIR ON LOS GATOS CREEK

(In acre-feet)

Season	Alamitos Diversion				Lexington Reservoir								
					Storage capacity: 25,000 acre-feet					Seasonal yield: 21,900 acre-feet			
	Supply	Distribution			Water supply			Distribution of water supply					
	Runoff	Release to Los Gatos Creek	Release to Alamitos Percolation Pond	Spill	Storage, October 1	Austrian Reser-voir spill	Runoff less di-versions between Austrian Dam and Lexing-ton Dam	Evapo-ration	Releases to			Spill	Storage, Septem-ber 30
Los Gatos Creek									San Tomas Aquinas Creek	Sara-toga Creek			
1935-36	16,100	13,100	3,000	0	0	0	16,100	0	10,700	3,500	1,900	0	0
36-37	26,400	20,200	5,500	700	0	0	22,300	600	13,500	5,100	3,100	0	0
37-38	66,900	15,700	11,600	39,600	0	13,600	53,600	1,100	31,200	8,800	5,600	18,900	1,600
38-39	6,500	6,500	0	0	1,600	0	2,000	0	3,600	0	0	0	0
1939-40	33,600	17,000	9,000	7,600	0	4,800	38,300	1,000	25,600	8,100	5,300	700	2,400
40-41	51,000	18,700	8,900	23,400	2,400	13,900	52,200	1,100	31,000	6,500	4,300	19,600	6,000
41-42	35,400	25,000	9,700	700	6,000	7,400	32,400	1,100	26,900	8,900	5,600	0	3,300
42-43	25,500	21,800	3,100	600	3,300	3,700	20,600	300	17,700	7,100	2,500	0	0
43-44	14,800	14,800	0	0	0	0	8,900	0	6,700	1,900	300	0	0
1944-45	18,500	13,900	2,800	1,800	0	1,600	18,000	0	12,400	5,200	1,800	0	0
45-46	12,100	12,100	0	0	0	800	12,500	0	8,800	3,200	1,000	0	0
46-47	3,300	3,300	0	0	0	0	3,000	0	3,000	0	0	0	0
47-48	5,200	5,200	0	0	0	0	4,100	0	3,200	900	0	0	0
AVERAGES	24,200	14,400	4,100	5,700		3,500	21,900	400	14,900	4,600	2,400	3,000	

SANTA CLARA VALLEY INVESTIGATION

SEASONAL SUMMARY OF MONTHLY YIELD STUDY, LITTLE FRANCIS
RESERVOIR ON SAN FRANCISQUITO CREEK

(In acre-feet)

Storage capacity: 7,300 acre-feet

Seasonal yield: 3,000 acre-feet

Season	Water supply		Distribution of water supply			
	Storage, October 1	Estimated runoff, San Francisquito Creek	Evaporation	Demand	Spill	Storage, September 30
1935-36	0	9,800	500	2,400	1,800	5,100
36-37	5,100	15,800	600	3,000	12,100	5,200
37-38	5,200	27,200	600	3,000	23,500	5,300
38-39	5,300	500	500	3,000	0	2,300
1939-40	2,300	18,400	600	3,000	12,000	5,100
40-41	5,100	23,300	600	3,000	19,300	5,500
41-42	5,500	18,400	600	3,000	15,100	5,200
42-43	5,200	13,100	600	3,000	9,500	5,200
43-44	5,200	3,000	500	3,000	0	4,700
1944-45	4,700	9,000	600	3,000	4,900	5,200
45-46	5,200	5,900	600	3,000	2,400	5,100
46-47	5,100	700	400	3,000	0	2,400
47-48	2,400	1,300	300	3,000	0	400
AVERAGES		11,200	500	3,000	7,700	

YIELD STUDY, ZAYANTE RESERVOIR ON ZAYANTE CREEK

(In acre-feet)

Storage capacity: 6,900 acre-feet

Seasonal yield: 4,000 acre-feet

Season	November-May			June-October				Storage, end of October	Spill, end of May
	Runoff	Demand, 40 per cent of seasonal demand	Storage, end of May	Demand, 60 per cent of seasonal demand	Apparent storage, end of October	Average summer storage	Evaporation		
1935-36	8,600	1,600	6,900	2,400	4,500	5,700	300	4,200	100
36-37	6,600	1,600	6,900	2,400	4,500	5,700	300	4,200	2,300
37-38	15,800	1,600	6,900	2,400	4,500	5,700	300	4,200	11,500
38-39	2,000	1,600	4,700	2,400	2,300	3,500	200	2,100	0
1939-40	14,800	1,600	6,900	2,400	4,500	5,700	300	4,200	8,400
40-41	22,800	1,600	6,900	2,400	4,500	5,700	300	4,200	18,500
41-42	13,600	1,600	6,900	2,400	4,500	5,700	300	4,200	9,300
42-43	10,300	1,600	6,900	2,400	4,500	5,700	300	4,200	6,000
43-44	4,100	1,600	6,700	2,400	4,300	5,500	300	4,000	0
1944-45	7,500	1,600	6,900	2,400	4,500	5,700	300	4,200	3,000
45-46	5,500	1,600	6,900	2,400	4,500	5,700	300	4,200	1,200
46-47	2,500	1,600	5,100	2,400	2,700	3,900	200	2,500	0
47-48	2,700	1,600	3,600	2,400	1,200	2,400	200	1,000	0
AVERAGES	9,000	1,600		2,400			300		4,600

SEASONAL SUMMARY OF MONTHLY YIELD STUDY, UVAS RESERVOIR ON UVAS CREEK

Storage capacity: 34,000 acre-feet

(In acre-feet)

Seasonal yield: 17,400 acre-feet

Season	Water supply		Distribution of water supply				
	Storage, October 1	Runoff, Uvas Creek	Evaporation	Releases to		Spill	Storage, September 30
				Uvas Creek	Llagas Creek		
1932-33.....	0	5,600	0	1,800	3,900	0	0
33-34.....	0	10,100	200	1,700	8,100	0	0
1934-35.....	0	15,500	400	3,500	11,600	0	0
35-36.....	0	25,300	1,200	3,800	12,500	0	7,800
36-37.....	7,800	31,400	1,400	5,300	16,500	0	16,000
37-38.....	16,000	68,000	1,600	4,600	14,100	40,700	23,000
38-39.....	23,000	4,600	200	4,700	22,700	0	0
1939-40.....	0	44,500	1,600	3,400	8,400	8,700	22,400
40-41.....	22,400	57,500	1,600	4,500	12,000	36,600	25,200
41-42.....	25,200	38,800	1,600	4,500	13,900	18,200	25,800
42-43.....	25,800	27,800	1,500	4,800	23,000	8,100	16,200
43-44.....	16,200	17,300	900	6,100	26,500	0	0
1944-45.....	0	25,000	1,000	4,500	17,500	0	2,000
45-46.....	2,000	15,200	0	3,400	13,800	0	0
46-47.....	0	10,000	0	1,900	8,100	0	0
47-48.....	0	6,000	0	1,900	4,100	0	0
AVERAGES.....		25,200	800	3,800	13,600	7,000	

APPENDIX L
ESTIMATES OF COST

TABLE OF CONTENTS
ESTIMATES OF COST

	<i>Page</i>
Estimated Cost of Coyote Valley Well Field and Coyote Valley—San Jose Pipe Line -----	147
Estimated Cost of Calero-Los Gatos Creek Conduit-----	148
Estimated Cost of Little Francis Dam and Reservoir-----	149
Estimated Cost of Little Francis Treatment Plant and Conveyance System	150
Estimated Cost of Zayante Dam and Reservoir-----	151
Estimated Cost of Zayante-Los Gatos Pumping Plant and Pine Line-----	152
Estimated Cost of Uvas Dam and Reservoir-----	153
Estimated Cost of Uvas-Llagas Conduit -----	154
Estimated Cost of Llagas Creek Percolation Dams-----	154

ESTIMATED COST OF COYOTE VALLEY WELL FIELD AND COYOTE VALLEY-SAN JOSE PIPE LINE

(Based on prices prevailing in fall, 1954)

Average elevation of well field: 270 feet, U.S.G.S. datum

Number of wells: 7

Elevation of pipe outlet at 12th and Martha Streets, San Jose: 100 feet, U.S.G.S. datum

Capacity of pipe line: Variable from 2.1 to 15 second-feet
Length of pipe line: 12.8 miles

Item	Quantity	Unit price	Cost		Item	Quantity	Unit price	Cost
Capital Costs					Capital Costs—Continued			
Drilling, casing and developing 16-inch diameter wells, 250 feet deep	7 ea.	\$4,000.00	\$28,000		Administration and engineering, 10%-----			\$96,300
1,000 gpm units including pump, motor, starter, and installation-----	7 ea.	4,400.00	30,800		Contingencies, 15%-----			144,500
Increased pump cost for existing wells due to lowering of water table					Interest during construction, none			
Reinforced-concrete cylinder pipe in place		lump sum	95,000	\$153,800	TOTAL -----			\$1,204,000
30-inch diameter-----	13,700 lin.ft.	14.80	202,800		Annual Costs			
27-inch diameter-----	9,200 lin.ft.	12.80	117,800	320,600	Interest, 3.5%-----			\$42,100
Reinforced-concrete pipe in place					Repayment, 0.763%-----			9,200
30-inch diameter-----	6,600 lin.ft.	13.35	88,100		Replacement, 1.0%-----			12,000
27-inch diameter-----	30,400 lin.ft.	10.80	328,300		General expense, 0.32%-----			3,900
24-inch diameter-----	2,600 lin.ft.	8.60	22,400		Operation and maintenance, 0.5%-----			6,000
21-inch diameter-----	1,300 lin.ft.	7.00	9,100		Electric energy			
18-inch diameter-----	2,600 lin.ft.	6.05	15,700		For 7—1,000 gpm wells			6,800
14-inch diameter-----	1,300 lin.ft.	4.35	5,700	469,300	For existing wells-----			10,800
Pavement excavation and repair-----		lump sum	3,300		TOTAL -----			\$90,800
Pipe jacking-----		lump sum	4,000					
Rights of way-----	3 ac.	4,000	12,000					
Clearing-----	2 ac.	100.00	200	19,500				
Subtotal -----				\$963,200				

SANTA CLARA VALLEY INVESTIGATION

ESTIMATED COST OF CALERO-LOS GATOS CREEK CONDUIT

(Based on prices prevailing in fall, 1954)

Main conduit

Elevation of crest of weir on Arroyo Calero: 383 feet, U.S.G.S. datum

Elevation of crest of weir on Alamitos Creek: 372 feet, U.S.G.S. datum

Elevation of outlet at Vasona Dam: 305 feet, U.S.G.S. datum

Capacity of conduit: 50 second-feet

Length of conduit

Unlined canal: 9.1 miles

Reinforced-concrete pipe: 4.8 miles

Guadalupe Creek intercepting conduit

Elevation of crest of weir: 347 feet, U.S.G.S. datum

Capacity of conduit: 25 second-feet

Length of conduit

Unlined canal: 1.2 miles

Item	Quantity	Unit price	Cost	Item	Quantity	Unit price	Cost
Capital Costs				Capital Costs—Continued			
Main conduit				Administration and engineering, 10%-----			\$81,400
Diversion structure				Contingencies, 15%-----			122,100
Arroyo Calero-----		lump sum	\$17,000	Interest during construction, none			
Alamitos Creek-----		lump sum	8,000	TOTAL-----			\$1,017,600
Canal excavation-----	62,500 cu.yd.	\$0.45	28,100	Annual Costs			
48-inch diameter reinforced-concrete pipe in place: (including blowoff and air valves)				Interest, 3.5%-----			\$35,600
125-foot maximum head-----	700 lin.ft.	25.90	18,100	Repayment, 0.763%-----			7,800
100-foot maximum head-----	5,800 lin.ft.	23.70	137,500	Replacement			
75-foot maximum head-----	10,100 lin.ft.	21.90	221,200	Pipe line, 1.0%-----			8,600
50-foot maximum head-----	9,000 lin.ft.	20.35	183,200	Canal, 0.02% (negligible)			
25-foot maximum head-----	3,800 lin.ft.	19.10	72,600	General expense, 0.32%--			3,300
Pavement excavation and repair-----		lump sum	3,000	Operation and maintenance			
Transitions-----	19 ea.	100.00	1,900	Pipe line, 0.5%-----			4,000
Farm crossings-----	20 ea.	400.00	8,000	Canal, 1.0%-----			2,100
Fence-----	18.2 mi.	1,200.00	21,800	TOTAL-----			\$60,800
Rights of way-----		lump sum	68,000				
Clearing-----	29 ac.	100.00	2,900				
			\$791,300				
Guadalupe Creek intercepting canal							
Diversion structure-----		lump sum	12,000				
Canal excavation-----	5,100 cu.yd.	0.80	4,100				
Culverts-----	3 ea.	400.00	1,200				
Rights of way-----		lump sum	5,000				
Clearing-----	5 ac.	100.00	500				
			22,800				
Subtotal, all items-----			\$814,100				

ESTIMATED COST OF LITTLE FRANCIS DAM AND RESERVOIR

(Based on prices prevailing in fall, 1954)

Elevation of crest of dam: 300 feet, U.S.G.S. datum

Capacity of reservoir to crest of spillway: 7,300 acre-feet

Elevation of crest of spillway: 290 feet

Capacity of spillway with 4-foot freeboard: 9,000 second-feet

Height of dam to spillway crest, above stream bed: 81 feet

Item	Quantity	Unit price	Cost	Item	Quantity	Unit price	Cost
Capital Costs				Capital Costs—Continued			
Dam				Outlet works—Continued			
Diversion and care of stream		lump sum	\$10,000	Control house		lump sum	\$2,000
Stripping and preparation of foundation	62,600 cu.yd.	\$0.50	31,300	4-foot by 5-foot headgate for diversion conduit		lump sum	500
Excavation for embankment							\$69,300
Impervious	223,000 cu.yd.	0.40	89,200	Reservoir			
Embankment				Improvements		lump sum	83,000
Impervious	178,600 cu.yd.	0.35	62,500	Land	350 ac.	\$2,000.00	700,000
Pervious, salvage	234,300 cu.yd.	0.40	93,700		50 ac.	200.00	10,000
Riprap	18,100 cu.yd.	3.00	54,300	Utilities		lump sum	4,000
Drilling grout holes	13,600 lin.ft.	3.00	40,800	Road relocation		lump sum	53,000
Pressure grouting	9,070 cu.ft.	4.00	36,300	Clearing reservoir lands		lump sum	20,000
			\$418,100	Livestock fence	5 mi.	1,200.00	6,000
							876,000
Spillway				Subtotal			\$1,762,100
Excavation				Administration and engineering, 10%			176,200
Common	218,200 cu.yd.	0.40	87,300	Contingencies, 15%			264,300
Rock	3,000 cu.yd.	1.50	4,500	Interest during construction, none			
Concrete	6,350 cu.yd.	35.00	222,300				
Reinforcing steel	476,000 lb.	0.15	71,400				
Riprap	4,400 cu.yd.	3.00	13,200				
			398,700	TOTAL			\$2,202,600
Outlet works							
Excavation				Annual Costs			
Common	300 cu.yd.	1.00	300	Interest, 3.5%			\$77,100
Rock	700 cu.yd.	5.00	3,500	Repayment, 0.763%			16,800
Concrete				Replacement, 0.07%			1,500
Pipe encasement	540 cu.yd.	30.00	16,200	Operation and maintenance			1,500
Inlet and control box	150 cu.yd.	60.00	9,000	General expense, 0.32%			7,000
Steel pipe, 36-inch diameter							
	47,800 lb.	0.25	12,000				
Reinforcing steel	82,000 lb.	0.15	12,300				
Gate valve, 36-inch diameter, and actuators		lump sum	6,300				
Hollow jet valve, 30-inch diameter		lump sum	7,200				
				TOTAL			\$103,900

ESTIMATED COST OF LITTLE FRANCIS TREATMENT PLANT AND CONVEYANCE SYSTEM

(Based on prices prevailing in fall, 1954)

Capacity of conduit to treatment plant: 6.5 million gallons per day
 Capacity of treatment plant: 5 million gallons per day
 Capacity of distribution reservoir: 2 million gallons
 Total installed capacity of pumping plant: 10 million gallons per day

Capacity of conduit to city distribution system: 9.7 million gallons per day
 Length of conduit to treatment plant: 8,800 feet
 Length of pump line to distribution reservoir: 3,600 feet
 Length of conduit to city distribution system: 8,500 feet

Item	Quantity	Unit price	Cost		Item	Quantity	Unit price	Cost	
Capital Costs					Capital Costs—Continued				
Conduit to treatment plant					Administration and engineering, 10%-----				\$27,500
Canal					Contingencies, 15%-----				41,300
Excavation-----	1,650 cu.yd.	\$0.80	\$1,300		Interest during construction, none-----				
Trimming-----	7,240 sq.yd.	0.75	5,400						
Shotcrete lining-----	7,240 sq.yd.	2.75	19,900		TOTAL, pipe line, distribution reservoir, and pipe line to distribution system-----				\$344,000
Fence, livestock-----	3.2 mi.	1,200.00	3,800						
Structures-----		lump sum	1,400		TOTAL-----				\$1,174,000
20-inch diameter welded steel pipe, No. 10 gage-----	300 lin.ft.	7.90	2,400						
Rights of way-----	3.9 ac.	2,000.00	7,800	\$42,000					
Subtotal-----				\$42,000					
Administration and engineering, 10%-----				4,200	Annual Costs				
Contingencies, 15%-----				6,300	Conduit to treatment plant				
Interest during construction, none-----					Interest, 3.5%-----				\$1,800
TOTAL, conduit to treatment plant-----				\$52,500	Repayment, 0.763%-----				400
Treatment and pumping plants					Replacement, 0.02%, negligible operation and maintenance, 0.5%-----				300
Treatment plant-----		lump sum	\$570,000		General expense, 0.32%-----				200
Pumping plant-----		lump sum	42,000		TOTAL, conduit to treatment plant-----				\$2,700
Rights of way-----	5 ac.	2,000.00	10,000	622,000	Treatment and pumping plants				
Subtotal-----				\$622,000	Interest, 3.5%-----				27,200
Administration and engineering, 10%-----				62,200	Repayment, 0.763%-----				5,900
Contingencies, 15%-----				93,300	Replacement, 1.2%-----				9,300
Interest during construction, none-----					Operation and maintenance-----				44,300
TOTAL, treatment and pumping plants-----				\$777,500	General expense, 0.32%-----				2,500
Pipe line, distribution reservoir, and pipe line to distribution system					Insurance, 0.12%-----				900
Pipe line					Electrical energy-----				4,100
20-inch diameter welded steel pipe, No. 10 gage-----	3,600 lin.ft.	7.90	28,400		TOTAL, treatment and pumping plants-----				\$94,200
Pavement excavation and repair-----	800 lin.ft.	1.50	1,200		Pipe line, distribution reservoir, and pipe line to distribution system				
Stand-by reservoir-----		lump sum	135,000		Interest, 3.5%-----				12,000
Pipe line to distribution system					Repayment, 0.763%-----				2,600
22-inch diameter welded steel pipe, No. 7 gage-----	8,500 lin.ft.	11.60	98,600		Replacement, 1.00%-----				3,400
Rights of way-----	6 ac.	2,000.00	12,000	275,200	Operation and maintenance, 0.5%-----				1,700
Subtotal-----				\$275,200	General expense, 0.32%-----				1,100
					TOTAL, pipe line, distribution reservoir, and pipe line to distribution system-----				\$20,800
					TOTAL-----				\$117,700

ESTIMATED COST OF ZAYANTE DAM AND RESERVOIR

(Based on prices prevailing in fall, 1954)

Elevation of crest of dam: 616 feet, U.S.G.S. datum

Capacity of reservoir to crest of spillway: 6,900 acre-feet

Elevation of crest of spillway: 603 feet

Capacity of spillway with 5-foot freeboard: 8,900 second-feet

Height of dam to spillway crest, above stream bed: 127 feet

Item	Quantity	Unit price	Cost		Item	Quantity	Unit price	Cost	
Capital Costs					Capital Costs—Continued				
Dam					Outlet works—Continued				
Diversion and care of stream		lump sum	\$10,000		Gate valve, 30-inch diameter, manual control	1 ea.	\$3,000	\$3,000	
Stripping and preparation of foundation	76,600 cu.yd.	\$1.00	76,600		Hollow jet valve, 24-inch diameter		lump sum	5,400	
Excavation for embankment					Control house		lump sum	2,000	\$96,000
Impervious	147,400 cu.yd.	0.65	95,800		Reservoir				
Pervious	212,250 cu.yd.	0.60	127,400		Land and improvements		lump sum	77,500	
Embankment					Public utilities		lump sum	128,400	
Impervious	128,200 cu.yd.	0.25	32,100		Clearing reservoir lands	168 ac.	500	84,000	289,900
Pervious	212,250 cu.yd.	0.20	42,500						
Pervious, salvage	81,850 cu.yd.	0.30	24,500		Subtotal				\$1,039,500
Riprap	11,500 cu.yd.	3.00	34,500		Administration and engineering, 10%				103,900
Drilling grout holes	2,580 lin.ft.	3.00	7,700		Contingencies, 15%				156,000
Pressure grouting	1,720 cu.ft.	4.00	6,900	\$458,000	Interest during construction, none				
Spillway					TOTAL				\$1,299,400
Excavation	86,300 cu.yd.	1.50	129,500		Annual Costs				
Concrete	1,430 cu.yd.	35.00	50,000		Interest, 3.5%			\$45,500	
Reinforcing steel	107,250 lb.	0.15	16,100	195,600	Repayment 0.763%			9,900	
Outlet works					Replacement, 0.07%			900	
Excavation	1,500 cu.yd.	4.00	6,000		Operation and maintenance			2,500	
Concrete, pipe encasement	902 cu.yd.	30.00	27,100		General expense, 0.32%			4,200	
Steel pipe, 36-inch and 48-inch diameter	115,900 lb.	0.25	29,000		TOTAL				\$63,000
Reinforcing steel	90,200 lb.	0.15	13,500						
Gate valve, 18-inch diameter, and actuators	4 ea.	2,500	10,000						

ESTIMATED COST OF ZAYANTE-LOS GATOS PUMPING PLANT AND PIPE LINE

(Based on prices prevailing in fall, 1954)

Elevation of reservoir outlet: 500 feet, U.S.G.S. datum

Capacity of pumping plant: 20 second-feet

Elevation of pipe line outlet on Los Gatos Creek: 895 feet, U.S.G.S. datum

Length of pipe line: 6.4 miles

Item	Quantity	Unit price	Cost	Item	Quantity	Unit price	Cost
Capital Costs				Annual Costs			
Pumping plant				Pumping plant			
3,000 gpm units; pump, motor, and electrical equipment	3 ea.	\$20,800	\$62,400	Interest, 3.5%			\$4,200
Valves				Repayment, 0.763%			900
10-inch diameter, check	3 ea.	600	1,800	Replacement, 1.2%			1,400
10-inch diameter, gate	4 ea.	500	2,000	Operation and maintenance			20,000
Concrete structure		lump sum	32,000	General expenses, 0.32%			400
			\$96,200	Insurance, 0.12%			100
				Electrical energy			20,300
Subtotal			\$96,200	TOTAL, pumping plant			\$47,300
Administration and engineering, 10%			9,600	Pipe line			
Contingencies, 15%			14,400	Interest, 3.5%			\$43,300
Interest during construction, none				Repayment, 0.763%			9,400
TOTAL, pumping plant			\$120,200	Replacement			
Pipe line				Pipe line, 1.0%			6,100
30-inch diameter welded steel pipe supported on concrete saddles	33,800 lin.ft.	\$14.50	\$490,100	Tunnel, 0.02%			100
Tunnel portal clearing		lump sum	500,000	Operation and maintenance			6,200
			\$990,100	General expense, 0.32%			4,000
Subtotal			\$990,100	TOTAL, pipe line			\$69,100
Administration and engineering, 10%			99,000	TOTAL			\$116,400
Contingencies, 15%			148,500				
Interest during construction, none							
TOTAL, pipe line			\$1,237,600				
TOTAL			\$1,357,800				

ESTIMATED COST OF UVAS DAM AND RESERVOIR

(Based on prices prevailing in fall, 1954)

Elevation of crest of dam: 549 feet, U.S.G.S. datum

Elevation of crest of spillway: 534 feet

Height of dam to spillway crest, above stream bed: 142 feet

Capacity of reservoir to crest of spillway: 34,000 acre-feet

Capacity of spillway with 5-foot freeboard: 20,000 second-feet

Item	Quantity	Unit price	Cost		Item	Quantity	Unit price	Cost	
Capital Costs					Capital Costs—Continued				
Dam					Outlet works—Continued				
Diversion and care of stream			lump sum	\$20,000	Hollow jet valve, 30-inch diameter		lump sum	\$7,200	
Stripping and preparation of foundation	105,200 cu.yd.	\$0.70	73,600		Control house		lump sum	2,000	
Excavation for embankment					2-foot by 2-foot canal headgate		lump sum	200	\$95,300
Impervious	916,700 cu.yd.	0.40	366,700		Reservoir				
Pervious	1,498,000 cu.yd.	0.35	524,300		Land and improvements, road relocation, and public utilities		lump sum	\$512,000	
Embankment					Clearing reservoir lands	650 ac.	\$200	130,000	\$642,000
Impervious	733,400 cu.yd.	0.35	256,700		Subtotal				\$2,785,700
Pervious	1,273,000 cu.yd.	0.30	381,900		Administration and engineering, 10%				278,600
Pervious, salvage	158,700 cu.yd.	0.30	47,600		Contingencies, 15%				417,800
Riprap	46,100 cu.yd.	3.00	138,300		Interest during construction, one-half of construction period at 3.5%				121,900
Drilling grout holes	8,130 lin.ft.	3.00	24,400		TOTAL				\$3,604,000
Pressure grouting	5,410 cu.ft.	4.00	21,600	\$1,855,100	Annual Costs				
Spillway					Interest, 3.5%				\$126,100
Excavation					Repayment, 0.763%				27,500
Common	15,000 cu.yd.	0.45	6,800		Replacement, 0.07%				2,500
Rock	60,000 cu.yd.	1.50	90,000		Operation and maintenance				5,900
Concrete	2,185 cu.yd.	35.00	76,500		General expense, 0.32%				11,500
Reinforcing steel	133,000 lb.	0.15	20,000	193,300	TOTAL				\$173,500
Outlet works									
Excavation									
Common	900 cu.yd.	1.00	900						
Rock	1,000 cu.yd.	5.00	5,000						
Concrete									
Pipe encasement	700 cu.yd.	30.00	21,000						
Inlet and control box	270 cu.yd.	60.00	16,200						
Steel pipe, 36-inch diameter									
Reinforcing steel	71,600 lb.	0.25	17,900						
Reinforcing steel	124,000 lb.	0.15	18,600						
Gate valve, 36-inch diameter, and actuators			lump sum	6,300					

SANTA CLARA VALLEY INVESTIGATION

ESTIMATED COST OF UVAS-LLAGAS CONDUIT

(Based on prices prevailing in fall, 1954)

Elevation of Uvas Dam outlet: 425 feet, U.S.G.S. datum

Length of conduit

Elevation of Llagas Creek stream bed at conduit outlet: 350 feet,
U.S.G.S. datum

Reinforced-concrete pipe: 1.8 miles

Unlined canal: 1.5 miles

Capacity of conduit: 50 second-feet

Item	Quantity	Unit price	Cost	Item	Quantity	Unit price	Cost
Capital Costs				Annual Costs			
48-inch diameter rein- forced-concrete pipe, in place-----	9,500 lin.ft.	\$20.35	\$193,300	Interest, 3.5%-----			\$9,600
Canal-----				Repayment, 0.763%-----			2,100
Excavation-----	6,950 cu.yd.	0.70	4,900	Replacement-----			
Compacted embank- ment-----	6,250 cu.yd.	0.15	900	Pipe line, 1.00%-----			2,500
Farm crossings-----	8 ea.	350.00	2,800	Canal and chute, 0.02% (negligible)-----			
Chute-----		lump sum	9,000	General expense, 0.32%--			900
Rights of way-----		lump sum	8,000	Operation and mainte- nance-----			1,500
Clearing-----	2 ac.	100.00	200				
			\$219,100	TOTAL -----			\$16,600
Subtotal-----			\$219,100				
Administration and en- gineering, 10%-----			21,900				
Contingencies, 15%-----			32,900				
Interest during construc- tion, none-----							
TOTAL -----			\$273,900				

ESTIMATED COST OF LLAGAS CREEK PERCOLATION DAMS

(Based on prices prevailing in fall, 1954)

Type of dam: Rock in chain link wire mesh

Average width: 100 feet

Number: 23

Length of flooded area: From Llagas Avenue to Rucker Avenue, 22,200 feet

Height: 3 feet

Area flooded: 50 acres

Item	Quantity	Unit price	Cost	Item	Quantity	Unit price	Cost
Capital Costs				Annual Costs			
Riprap-----	2,800 cu.yd.	\$4.00	\$11,200	Interest, 3.5%-----			\$1,400
Galvanized steel pipe, 2- inch diameter-----	6,000 lin.ft.	1.00	6,000	Repayment, 0.763%-----			300
¼-inch galvanized steel cable (7 wire)-----	4,000 lin.ft.	1.00	4,000	Replacement, 1.0%-----			400
¾-inch chain link mesh, No. 14 gage-----	8,200 sq.yd.	0.75	6,200	Operation and mainte- nance-----			1,900
No. 12 gage wire-----	500 sq.yd.	1.00	500	General expense, 0.32%-----			100
¾-inch steel cable-----	4,100 lin.ft.	1.00	4,100				
			\$32,000	TOTAL -----			\$4,100
Subtotal-----			\$32,000				
Administration and en- gineering, 10%-----			3,200				
Contingencies, 15%-----			4,800				
Interest during construc- tion, none-----							
TOTAL -----			\$40,000				

O